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SHIPPINGPORT
NUCLEAR POWER STATION

Alleged Health Effects

Prepared By

GOVERNOR'S FACT FINDING COMMITTEE

1974

FOREWARD

New technological advances crowd upon our society with ever increasing pressures, overwhelming the capacities of our social, political and psychological systems. The development of effective and flexible institutions to deal with the modern technological explosion becomes imperative if we are to preserve the values of our culture.

The allegations surrounding the Shippingport nuclear power plant represent quintessentially the issues that must be faced by society in dealing with the myriad problems arising from ever expanding scientific knowledge.

The operation of the Fact-Finding Committee appointed by Governor Shapp to investigate the Shippingport accusations demonstrates responsible social and political methods of evaluating modern technology.

I should like to thank Governor Shapp for forming the committee and providing the moral and material support that enabled the committee to carry on its work. I should also like to express my appreciation -- and sense of awe -- to the distinguished members of the committee for their diligence, high purpose and outstanding performance in carrying out their work.

The committee had no full time staff; civil servants from the Departments of Health and Environmental Resources provided the necessary staff services while continuing regularly assigned tasks. These dedicated men and women deserve a special commendation for their invaluable work.

Leonard Bachman, M.D.
Governor's Health Services
Director

TABLE OF CONTENTS

Committee Members.................................. II-V

Summary of Committee Findings...................... 1-3

Summary of Recommendations......................... 3-4

The Shippingport Controversy:

Background..................................... 5

Detailed Allegations........................... 5-9

Governor's Fact Finding Committee.............. 9-10

Principle Issues Investigated by the Committee...... 11

Discussion of Committee Findings, Conclusions and Recommendations.................................. 12

Evaluation of Radiation Allegations............ 13-32

Evaluation of Alleged Health Effects........... 33-40

Recommendations.................................... 41-43

Appendix A Tables.................................. 44-81

Appendix B A Non-Technical Description of the Operating Characteristics of a Pressurized Water Reactor...... 82-88

Appendix C Individual Committee Member's Comments........ 89-106

Bibliography....................................... 107-110

COMMITTEE MEMBERS

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Morris H. DeGroot, Ph.D. is a Professor of Mathematical Statistics at Carnegie-Mellon University and former Chairman of the Department of Statistics. He is a member of the Assembly of Behavioral and Social Sciences of the National Research Council, and is a Fellow of the American Statistical Association and the Institute of Mathematical Statistics. He serves on the editorial boards of the Journal of the American Statistical Association and the Annals of Statistics. He is the author of a book on statistical decision theory published in 1970 and a forthcoming book on probability and statistical inference.

Maurice K. Goddard is the Secretary of the Department of Environmental Resources. Secretary Goddard's career has been devoted to the protection and improvement of environmental resources. He was formerly the Secretary of Forests and Waters. Secretary Goddard received his Bachelor of Science Degree from the University of Maine in 1935 and was granted a Masters of Science from the University of California in 1938. He has served by Presidential Appointment as Commissioner on the Public Land Law Review Commission; as a Presidential Appointee to the Water Pollution Control Advisory Board and was appointed by the Surgeon General to the Public Health Services National Advisory Environmental Health Committee. Secretary Goddard serves as alternate for Milton J. Shapp on the Delaware River Basin Commission and the Susquehanna River Basin Commission.

Paul Kotin, M.D. is Provost and Vice President of Temple University Health Sciences Center. His scientific career is devoted to environmental health--both the chemical and physical hazards in the environment. He was formerly the director of the National Institute of Environmental Health Sciences. Currently, he is a consultant to the National Cancer Institute and the Environmental Protection Agency, a member of the American Association for Cancer Research, a member of the Scientific Committee of the Institute of Occupational and Environmental Health, Montreal, Canada, and serves on the editorial boards of Environmental Research, The American Journal of Pathology, and The International Review of Experimental Pathology.

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Edward P. Radford, M.D. is a Professor of Environmental Medicine at Johns Hopkins University School of Hygiene and Public Health. He is a consultant to the State of Maryland Occupational Health and Safety program, and a member of the Advisory Committee for the Maryland Bureau of Air Quality Control. He is also a member of the ad hoc Committee on Carbon Monoxide of the Committee on Biological Effects of Air Pollutants of the National Academy of Sciences. Formerly he served as a member of the National Academy of Sciences Committee on the Biological Effects of Ionizing Radiation and as Chairman of the Power Plants and Human Health and Welfare Studies Group of the State of Maryland.

Dr. Harry Smith, Jr., presently Dean of the School of Management at Rensselaer Polytechnic Institute in Troy, New York is a professional biostatistician. He received his Ph.D. in Applied Statistics from North Carolina State University majoring in Biostatistics at the School of Public Health. Active in the Health field, Dr. Smith has been a member of the Faculty in the School of Public

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J. Finton Speller, M.D. is the Secretary of Health for the Commonwealth of Pennsylvania. Dr. Speller was granted a Bachelor of Arts Degree from Lincoln University in 1932 and a Doctorate of Medicine from Howard University in 1940. He completed a Urologic Residency at Columbia Presbyterian Hospital in 1956. Dr. Speller has served as a Delegate to the 1971 White House Conference on Aging and as a Lecturer in the Department of Public Health Practice at the University of Pittsburgh, Graduate School of Public Health.

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SUMMARY

Allegations have been made concerning releases of radioactive material from the Shippingport Atomic Power Station and that these releases caused increases in certain diseases and mortality in the surrounding populations.

Governor Shapp established a Fact-Finding Committee to investigate the allegations and to make any recommendations the Committee deemed desirable. The Committee reviewed the allegations, held two days of hearings in Aliquippa, Pennsylvania, and consulted other sources and references before reaching the following conclusions and making specific recommendations. Detailed discussion of the Committee findings are incorporated in the full report.

Summary of Committee Findings

1. There is no substantial evidence that the quantities of radioactive materials released by the Shippingport Atomic Power Station have been greater than reported by the plant operators or allowed under either State or Federal Regulations. However, the absence of comprehensive off-site monitoring during plant operations precludes accurate verification of the data on plant releases. On-site monitoring data, including regular measurement of the primary coolant, along with the absence of significant amounts of long-lived radionuclides in the present environment do not support the allegation that large unreported releases occurred.

2. Based on the available health data, there is no systematic evidence to support the allegation that radioactive releases from the Shippingport plant had significant effects on the health of the population in the vicinity of the plant.

3. During the course of the investigation it became apparent that current, as well as past, environmental radiation monitoring programs are inadequately designed and carried out for determining the impact of radioactive releases on the environment. Environmental monitoring programs conducted in the vicinity of the reactor have not been properly reviewed by a qualified health physicist on a timely basis. Apparently, no qualified health physicist was in the employ of the Duquesne Light Company.

4. A precise determination of the radiation dose to the population in the vicinity of the plant was not possible due to poorly designed and unreliable monitoring data. There is insufficient evidence to conclude with certainty that the Shippingport plant was the cause of some higher than expected levels of radioactivity observed in 1971 and 1972. It is possible that some of these observed levels may have, indeed, been the results of inadequate and careless methods and procedures by NUS Corporation.

5. Crude mortality statistics, upon which the alleged health effects were based, are strongly influenced by a variety of factors other than radiation such as: age, sex, race, income, education, medical care, personal habits, etc. Furthermore, mortality statistics for small populations are influenced by systematic reporting errors of the cause of death and the place of residence of the deceased. This reporting bias may tend to overestimate mortality rates for more urban areas and, at the same time, to underestimate the rates for more rural areas.

The Committee found that published crude mortality statistics are unsatisfactory for making and evaluating the types of comparisons and associations used in the allegation.

6. There is widespread uneasiness about the hazards of nuclear reactors in the general public. During the course of the Committee's investigation, it becomes apparent that the nuclear industry and regulatory agencies have not developed either publicly credible or publicly accountable procedures to deal with these fears and concerns.

7. The format of the Aliquippa hearings proved to be satisfactory to both sides in the issue, in contrast to the legalistic public hearings usually held in matters of government policy. Especially important was the opportunity for those testifying to be questioned by people with expert knowledge in the field under discussion.

8. The academic scientific community (with the notable exception of a distinquished few) has failed to recognize its public responsibility to inform the public of both the risks and benefits that may be accrued from the use of nuclear energy or the use of available alternatives. The public looks to these independent experts in the academic community for credible information and perspective. The public responsibility of the scientific

academic community is not met solely by publishing articles in technical journals or in discussing issues among themselves at symposia.

Summary of Recommendations

1. In order to determine radiation exposure of the public, to determine compliance with applicable regulations, to verify results of the facility environmental monitoring program and to assure citizens living near nuclear facilities of adequate protection from radiation exposure, the Commonwealth Department of Environmental Resources should immediately begin an independent comprehensive environmental radiation monitoring program in the vicinity of all nuclear reactors within the State or near the State's borders. The results of these monitoring programs should be freely available to the public.

2. To assess the impact of nuclear power plants on both the environment and public health, it is necessary to have accurate and reliable environmental monitoring data. A quality control program for all environmental monitoring programs must be initiated immediately. It is incumbent upon the Federal Government to develop and regulate such a quality control program.

3. Adequate health physics program supervised and directed by a Certified Health Physicist should be initiated by all nuclear power plants. The plant environmental monitoring program should be under the direct control of the senior health physicist and a thorough review of all results should be made at frequent intervals.

4. With specific reference to the Beaver Valley and Shippingport plants the following recommendations are made:

   a. The Duquesne Light Company should be made the single accountable authority for both site environmental monitoring and operations management at the Shippingport - Beaver Valley site.

   b. The Atomic Energy Commission Directorate of Regulatory Operations should assume the regulatory authority for the Shippingport plant.

The above recommendations will end the duality in operations at the two facilities.

5. The Committee supports pending Federal Legislation that would reorganize the Atomic Energy Commission into two separate and distinct agencies. The first agency should be responsible for the regulation and safety of nuclear reactors, while a second separate agency would be responsible for the development of nuclear power facilities. The role of the AEC as both the promoter and regulator of nuclear power should cease.

6. In order to assess the effects of low-level radiation on human health, carefully designed epidemiological, clinical, pathological and laboratory studies should be conducted in coordination with proper radiation dose assessment programs.

7. The Commonwealth of Pennsylvania should initiate a program to improve both reporting and processing of vital statistics. This program should include: (a) improved reporting of residency for all births and deaths; (b) coding and reporting of both the underlying and contributory causes of death.

8. Mortality data released annually by the State Health Department should include both crude (unadjusted) and standardized (adjusted for demographic and social factors) rates for different geographic and political subdivisions. It is of particular importance that standardized rates be developed for populations around nuclear facilities.

9. Since cancer is significantly affected by environmental factors, the Department of Health should establish a statewide cancer registry (which may require new legislation making cancer a "reportable disease") and/or develop a systematic and comprehensive hospital and ambulatory care data system. A statewide system would provide the means for the proper evaluation and management of cancer related health problems.

THE SHIPPINGPORT CONTROVERSY

Background

The Shippingport Atomic Power Station is situated on the south bank of the Ohio River in Beaver County Pennsylvania, approximately one mile from the town of Midland and 25 miles from Pittsburgh. Owned by the Division of Naval Reactors of the Atomic Energy Commission, the station is operated by the Duquesne Light Company, Pittsburgh.

The first large-scale application of nuclear power for the production of commercial electric power, the Shippingport unit has been in continuous operation since December 1957. During this period two reactor cores have been operated.

Situated on the same site as the Shippingport plant are the sites for two new atomic power stations, Beaver Valley units I and II. The Beaver Valley plants are owned and will be operated by the Duquesne Light Company.

In 1971, a pre-operational environmental monitoring program was begun around the sites of the Beaver Valley units. The environmental monitoring program, as specified by the Atomic Energy Commission's Regulations, was conducted by the NUS Corporation under contract with the Duquesne Light Company.

In late 1972, when the results of the monitoring program were made public, some of the data appeared to indicate levels of radioactivity in the environment in excess of normal "background" levels. Since neither of the Beaver Valley units were operational, considerable attention was focused on Shippingport plant as a possible source of unreported releases of racioactive wastes to the environment.

Detailed Allegations

In February of 1973, Governor Shapp received a report from Dr. Ernest J. Sternglass, Professor of Radiological Physics at the University of Pittsburgh. In the report, Dr. Sternglass cited evidence indicating that the Shippingport Nuclear Power Station, " . . . had been the source of large amounts of radioactive fission products such as strontium-90 in the soil. the milk and air of Western Pennsylvania, far above levels experienced anywhere in the United States at that time . . ."

The following principle allegations of Dr. Sternglass are based primarily on data obtained from the environmental monitoring study conducted by the NUS Corporation and crude mortality rates published by the Pennsylvania Department of Health:

> *In 1971, an environmental monitoring program conducted by the NUS Corporation in the vicinity of Shippingport Atomic Power Station showed unusually high levels of strontium-90 in the soil. The highest levels observed occurred in the spring and summer of 1971. During this period, the amounts of strontium-90 decreased with distance from the Shippingport plant and subsequent to repairs carried out on the reactor, the levels of strontium-90 by January 1972 had delined to levels typical for the Eastern United States.*
>
> *Furthermore, in 1971 and early 1972, the levels of strontium-90 found in milk samples from six local dairies paralleled those measured in the soil near the plant site. The highest recorded level was 27 pCi/liter compared to the average concentration of 6 to 7 pCi/liter in Harrisburg and the rest of the United States.*
>
> *The Commonwealth of Pennsylvania routinely reports concentrations of strontium-90 in milk from various parts of the State. A comparison of strontium-90 concentrations in the Pittsburgh area milk for 1971 has shown the following:*
>
> > *a. Strontium-90 levels in the Pittsburgh area milk were slightly higher than levels observed in either Harrisburg or the average concentration reported for the United States.*
> >
> > *b. Strontium-90 concentrations for the Pittsburgh area milk were considerably lower than the levels observed in the six dairies around the Shippingport plant.*
>
> *The above observations are consistent with the fact that a portion of the Pittsburgh area milk comes from dairy farms within 10 to 20 miles from the plant.*
>
> *Between January and June of 1971, variations in the observed levels of strontium-90 in the milk from the six dairies within 10 miles of the plant followed*

the rises and declines of monthly electric power generation of the Shippingport plant.

The high levels of strontium-90 in soil and milk were accompanied by peaks in external radiation doses as measured at 20 different locations. The maximum dose-rate recorded on the plant site was 410 millirads per year (Station #43, March 19 to April 1, 1971). The maximum recorded dose-rate for the town of Shippingport was 371 millirems per year in March, 1971 followed by further peaks of 352, 292 and 306 in May, July and November.

The yearly average dose-rate for this site was 180 millirems. The permitted annual dose to the average individual is 175 millirems. Thus the dose rate for this site was 5.9% above the allowable dose.

The NUS study found significant concentrations of iodine-131 in milk obtained from six dairies within 10 miles of the plant. The highest concentration measured was 121 pCi/liter or 21% above the current permissible level set by the Federal Government. Nowhere else in the entire United States did iodine-131 exceed even one-tenth of this level. It should be noted, also, that the recent report by the National Academy of Sciences urges a hundred-fold lowering of the present permissible dose of iodine-131 to the general population.

Radioactivity in the Ohio River bottom sediment rose in April and May of 1971, according to the NUS study. Subsequently, the levels declined after the plant was shut down for repairs. The maximum level found in 1971 was ten times the minimum level found in 1959 by Dr. Maurice Shapiro, of the Graduate School of Public Health, University of Pittsburgh.

Published reports by the Environmental Protection Agency show no atmospheric nuclear testing by either France or China during the time period from January to June 1971. Furthermore, no underground weapons tests were conducted by the Atomic Energy Commission during this period. Therefore, these radiation levels could not be attributed to releases from such tests.

A recent analysis conducted by Dr. Ernest J. Sternglass has revealed that in 1964 and again in 1970 the gross beta radioactivity in the Ohio River, as measured one mile below plant exceeded, by many times, the activity measured 25 miles above the plant.

Using the measured flow in the Ohio River and the State Department of Environmental Resources' measurements of radioactivity in the rivers above and below the plant, the amounts of radioactivity added by the plant to the Ohio River during 12 month periods in 1964-65 and 1970 are estimated to have been 77 and 178 curies respectively. These estimated values must be compared with 0.58 curies permitted under the terms of the plant's Industrial Waste Permit issued by the Pennsylvania Sanitary Water Board, and 22.6 curies per year adopted by the Atomic Energy Commission.

The full consequences of these findings are brought to focus by the results of a study by Dr. Lester B. Lave at Carnegie-Mellon University. In a statistical analysis of 60 metropolitan areas in the United States, Dr. Lave's study implies that an increase of one picocurie of strontium-90 per liter of milk is estimated to increase the total mortality rate by 1.29 per 100,000 population.

The average excess strontium-90 in milk observed by the NUS Corporation in six dairies within ten miles of Shippingport was 12 pCi/liter. At this level the expected excess mortality would be 15 per 100,000 population. Since about one million people live within a radius of 30 miles of the plant and consume some of the milk and food produced in the area of the plant, it was concluded that in 1971 some 150 people died in excess of what would normally be expected.

This estimate is supported by the rise in infant mortality for the city of Aliquippa. Aliquippa is located nine miles east and downwind from the Shippingport plant. For the years 1970 and 1971, Aliquippa's infant mortality rates climbed to a twenty year high of 44.2 and 39.7 per 1000 births. These rates are more than double the overall state rates of 19.9 and 18.2. Yet, in 1949 and 1952, before Shippingport started and when local air

> *pollution was greater, Aliquippa's infant mortality rates had been as low as 16 per 1000 births.*
>
> *This estimate of health effects from Shippingport releases is further supported by examining infant mortality rates in other communities downstream along the Ohio River. In 1963 when reported gaseous releases increased, infant mortality rates also increased in the cities of East Liverpool, Ohio and Wheeling, West Virginia.*
>
> *The increase of infant mortality rates in Aliquippa was accompanied by increases in other conditions known to be associated with radiation exposure. Thus, out of 98 separate localities listed in the Annual Vital Statistics Reports of Pennsylvania, Aliquippa reached the highest mortality rates for diseases of early infancy in 1970, third highest in leukemia and fourth highest in both fetal mortality and percentage of underweight births.*
>
> *In sharp contrast, for 1964, when air pollution was greater but the reactor was shutdown, Aliquippa ranked 64th in infant mortality rate, 15th in diseases of early infancy, 34th in leukemia, eighth in fetal mortality and 51st in underweight births. Yet, the composition of the population remained essentially unchanged during the 1960's. The percent of non-white population represented 21 percent of the total in 1960 and 22 percent in 1970.*
>
> *Since Shippingport began operation, mortality rates due to cancers (including leukemia) and heart disease have increased among populations near the reactor.*
>
> *Dr. Sternglass concluded, "The seriousness of these findings puts into question the adequacy of existing release monitoring techniques and the competence or integrity of the individuals responsible for the safe operation of the Shippingport facility".*

The Governor's Fact-Finding Committee

Governor Shapp asked his Health Services Director, Leonard Bachman, M.D., to form a committee of impartial experts to conduct an investigation of the allegations.

Each committee member was asked to serve in the public interest without compensation other than direct expenses. The committee was charged by the Governor with the investigation of all the facts relevant to the significant allegations, and asked to render their expert opinions as to the validity of the allegations.

From the outset of the investigation it was apparent that there is a widespread uneasiness in the general public about the hazards of nuclear power. Contributing to this uneasiness are the facts that radiation can be harmful to health, that it is not detectable by our senses, that the devastation wrought by atomic bombs is well known, and that accidental releases of radioactivity have occurred from experimental reactors. Compounding this uneasiness is a lack of confidence in the procedures used by Federal agencies and private companies to assure adequate protection of the public against the harmful effects of radiation.

In the past, scientists conducting investigations such as this one would meet in closed sessions. The participants would not have been publicly accountable for their investigation. Both the Governor and the Committee strongly believe, however, that issues such as those raised in the allegations must be investigated in a completely open and publicly accountable way. A method of investigation was sought that would include the public, both as observers and participants, in the Committee's deliberations. As part of this open investigatory process, the press was invited to attend meetings of the Committee. Also, on July 31 and August 1, 1973 public hearings were held in the City of Aliquippa.

The format of the hearings was structured on the democratic principles found in a New England Town Meeting. Notices were published, inviting all interested parties to attend. Anyone who requested an opportunity to testify was accommodated. Committee members were permitted to question each witness so as to bring out details they considered necessary for the understanding of both the Committee and the public.

The Committee concluded that the format of the Aliquippa hearings proved satisfactory to both sides of the issue. However, as Dr. Irwin Bross states in his paper Adversary Science in Aliquippa, "This approach and this format, like any other, will only work well if the participants make a strong effort to use the system in a fair and sensible way."

Principle Issues Investigated by the Committee

The central issues of the allegations are that significant unrecorded releases of radioactive wastes to the environment have occurred at the Shippingport plant, that the amounts of radioactivity released were not reported by the operators of the plant possibly because their routine monitoring program failed to measure these releases, and that, as a result of these releases, measurable effects on the health of the population around the plant could be detected by examination of annual mortality data collected by the Pennsylvania Department of Health.

These allegations raised important subsidiary questions for the Committee's investigation such as:

1. Were there abnormally high levels of radiation in the vicinity of the Shippingport plant during the period 1957-1971?

2. Were there any abnormally high incidences of cancer (including leukemia), infant mortality and heart disease among the population living in the vicinity of the Shippingport reactor during the period 1957-1971?

3. Has environmental monitoring of radioactive releases from the Shippingport plant been such that we can confidently determine the impact of these releases on the environment and the resultant exposure to the population? Was there adequate supervision of radiation monitoring programs by a qualified health physicist?

4. In quantitative terms, what radiation doses to the population could be ascribed to plant operations as distinct from "natural background" radiation, fallout from nuclear weapons testing or other sources?

5. Given the multitude of factors that influence crude mortality rates, are these statistics adequate to make the type of association and comparisons that were made in the allegations? Also, what methods are available for studying possible associations between low level radiation exposure and health effects?

It is important to bear in mind that the matters set before the Committee were considered in light of the concept that a biological risk is associated with each incremental radiation dose. This concept is consistent with the approach adopted by the National Academy of Sciences in the report The Effects on Population of Exposure to Low Levels of Ionizing Radiation, known popularly as the BEIR Report.

DISCUSSION OF COMMITTEE FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Allegations have been made to the effect that the Shippingport Atomic Power Station released excessive amounts of radioactivity, and that these in turn had a deleterious and measurable effect on the health of the population in the greater Shippingport area. Numerous allegations correlating Shippingport releases with disease mortality patterns were made, both in the written testimony and oral testimony to the Committee. These charges were, in turn, rebutted in testimony by representatives of the operator of the facility, the Atomic Energy Commission, the Environmental Protection Agency and independent experts.

In addition, the Committee studied various documents including: (1) Shippingport on-site radioactivity release reports and operational reports (2) Shippingport on-site environmental monitoring data (3) Beaver Valley Power Station environmental monitoring data as reported by NUS Corporation (a consultant to Duquesne Light Company) (4) Pennsylvania Department of Environmental Resources Water Quality network data for the southwestern portion of Pennsylvania (5) Pennsylvania Department of Environmental Resources milk monitoring data for the greater Pittsburgh area and other locations in Pennsylvania and (6) Pennsylvania Department of Health's biostatistical data.

EVALUATION OF RADIATION ALLEGATIONS

The specific radiation allegations deal primarily with two time periods: (1) during plant shutdown in 1964-65 when a new core was installed, and (2) during the 1971-72 time period when NUS Corporation was conducting preoperational environmental monitoring data for the Beaver Valley Power Station (BVPS), located adjacent to the Shippingport Atomic Power Station.

During 1964-65 when the Shippingport plant reactor core was changed, the facility operator reported releases to both air and water. These reported releases were well within the maximum release levels allowed under both federal and state regulations. Although no off-site monitoring was done in 1964-65, the Shippingport on-site environmental monitoring program showed no significant increases in on-site environmental radioactivity levels.

During 1971-72, according to the allegations, the Shippingport plant had unreported releases of radioactive waste. The allegations were based on certain higher than expected values in environmental radiation data as reported by NUS Corporation as a result of its pre-operational surveillance activities around the site.

NUS Data Anomalies

Preoperational radiological surveillance data for the BVPS were published late in 1972 in the Environmental Report - Construction Permit Stage - Beaver Valley Power Station Unit II (Appendix D). Some of the data in that report appeared to be atypical. These data groups included: (1) ambient radiation measurements using thermoluminescent dosimeters (2) strontium-90 concentrations in milk (3) strontium-90 concentrations in soil and (4) iodine-131 concentrations in milk.

NUS Corporation subsequently refuted their data in testimony before this Committee and later under oath at an Atomic Energy Commission hearing on the environmental effects of the proposed Beaver Valley Nuclear Power Plants. The following exercise is made to discuss this data in an attempt to determine if these data could have been real. Such a retrospective analysis is difficult but the information and discussion are important relative to the task facing the Committee.

Thermoluminescent Dosimeter (TLD) Data

TLD devices are used for the measurement of external absorbed dose of electromagnetic radiation. Those TLD's used by NUS were packaged in such a way as to be made insensitive to alpha and beta radiation. Their sensitivity, then, is essentially restricted to gamma and x-radiations.

These devices, when properly used, measure external radiation from cosmic radiation, terrestrial radiation and radiations from airborne contamination (e.g., radioactive noble gases and other gamma emitting airborne releases from nuclear facilities.) These devices measure quantitatively the absorbed dose (rad) from essentially all electromagnetic ionizing radiations to which they are exposed. The period of their exposure begins with their preparatory annealing and ends with their reading. In addition to measuring radiation at the test site the TLD's respond to all gamma radiation in their environment enroute to the test site and the radiation in their environment enroute back to the laboratory where they are read. For this reason, when these devices are used to measure small increments or variations in ambient radiation, and when transit times are a large fraction of the test site exposure period, this transit exposure can be quite significant.

It was stated in the BVPS II environmental report that NUS Corporation had not corrected the TLD data for the transit dose. This procedure is contrary to accepted practice. Further investigation has disclosed that retrospective correction of those data would not possibly produce reliable results due to uncertainties in estimating absorbed dose to the TLD's while in transit.

It is apparent, then, that the TLD data in question are not useful in estimating external radiation levels in the vicinity of the site. Attempts by the Committee to correct the data for in-transit dose would be speculative. Due to the absence of any independent monitoring of ambient radiation levels in the general environment, no external dose can be estimated for the period in question.

Thermoluminescent dosimeters can only be useful in assessing external dose around the reactor when used through a proper Quality Assurance Program. A proper program includes: (1) selection of a proper phosphor (2) correction for energy dependence characteristics (3) proper dosimeter calibration techniques and

(4) proper statistical adjustments. TLD's should not be considered for detection of beta emitters or for gamma increases of less than a few per cent above background.

Strontium-90 Concentrations in Soil

The practice of including soil sampling in environmental radiological surveillance programs, unless properly done, is of questionable value. The matter of uncertainties inherent in soil history, sampling techniques, soil chemistry, slope, ground cover and root mat, for example, renders the subsequent interpretation of data difficult both within a given site study and comparisons with other studies. Considerable know-how is necessary to assure reliable results. With reliable results in hand, even within a given study, the meaning of the data at times is difficult to establish with certainty.

The original set of soil sampling data submitted by NUS for the BVPS site for the period from the second quarter of 1971 through the first quarter of 1972 did, however, contain some values which were well in excess of what might be considered typical, in light of Shippingport release data and fallout history.

A program to determine the validity of the reported soil data was instituted by NUS. NUS retrieved a few soil samples which it claimed were the samples collected in April 1971 and September 1971. These samples were split for reanalysis by several laboratories including federal laboratories, and NUS.

The results of the intercomparison suggest that the original data for Sr-90 in soil as reported by NUS were biased. The biases lead to the reporting of false-high values. The sources of the bias appear to be an error in counter calibration and a radioanalytic error. The results of the reanalyses also suggested that the concentrations of Sr-90 in soil near Shippingport were no higher than elsewhere at the time of collection (provided these recently retrieved NUS soil samples are in fact typical of the earlier samples.)

Soil samples were collected and analyzed by the Environmental Protection Agency in February 1973. Due to the half-life of strontium-90 and the fact that no extensive world-wide fallout has occurred, levels found should have approximated the levels found in 1971, all other factors being equal including lack of soil translocation. Levels found in 1973 were 2 to 10 times lower than those reported by NUS in 1971. Changes of this magnitude over this short period of time would not be expected (1) unless sample collection or analytical techniques were changed, (2) unless there has been considerable soil translocation and (3) unless the early Sr-90 values included some of the Sr-89 present at that time.

It is also important to note that none of the soil samples collected by NUS were taken on the dairy farms which were selected for milk Sr-90 analysis. Radioactivity concentration in soil is meaningless unless one attempts to associate it with uptake by plants and subsequently by animals. It can be useful however to determine trends if background levels were first established. This was not done.

Due to a variety of uncertainties, soil sampling is of questionable value for assessing base line trends in environmental radiation studies for nuclear facilities unless the sampling is conducted under well planned and controlled conditions. This practice should be eliminated unless the program is placed under the direction of a competent health physicist with a strong background in environmental sciences, who will assure quality control and develop the methodology for normalizing the data.

Strontium-90 Concentrations in Milk

Sampling of fresh fluid milk has long been recognized and accepted as a very worthwhile method for the timely detection of biologically important radioactive materials in the environment. At the same time, it provides a reasonable estimate of dose to the most sensitive sector of the population namely, infants and young children.

Milk sampling was included in the monitoring program at Beaver Valley Power Station. The samples were analyzed for Sr-90, among other radionuclides. During almost all of calendar year 1971, concentrations reported by NUS ranged to 2 to 3 times the concentration for the Pittsburgh milk shed. Although there is no reason to expect individual dairy farm data to replicate milk shed data, the dairy farm data were consistently higher than expected.

A program to assess the validity of the milkborne Sr-90 data was implemented by NUS. NUS claims to have retrieved residues of several of the subject milk samples. These residues for samples of the period July through September 1971, were analyzed by NUS and by federal laboratories. The results of those intercomparisons were similar to the results of the soilborne Sr-90 investigation, to the effect that the originally reported data for milkborne Sr-90 were false-high. The sources of this bias, again, were errors in instrument calibration plus errors in radioanalytic techniques. The results of the reanalysis suggested that the concentrations in the controversial milk samples were probably no different from those reported elsewhere (provided the recently retrieved NUS milk samples are in fact typical of the earlier milk samples).

Due to the nature of the techniques used to assay for Sr-89 and their heavy dependence on SR-90 analytic accuracy, probably it is prudent to reject the Sr-89 values given in the original NUS report. Unfortunately, however, good data on the Sr-89/SR-90 ratio would have provided a valuable clue to the source of environmental strontium.

Several indicators in the original milk data rendered the reported Sr-90 values suspect. These factors include the relationships between Sr-90 and Cs-137, and the variation of Sr-90 concentrations with time.

Strontium-90 and Cs-137 are two of many radioisotopes which are spawned in the fission process. The fission event may originate in a nuclear weapon or in a reactor.

The overwhelmingly significant routes of entry of these radioisotopes into cow's milk is by way of ingested vegetation. Radioactive materials become incorporated in this chain by absorption through the roots of plants and by deposition on plant foliage.

For a variety of reasons, Sr-90 is generally incorporated in plant material through both mechanisms, root uptake and foliar deposition. In contrast, Cs-137 is incorporated in plant material predominately by foliar deposition, since Cs-137 is tenaciously bound in soil and is, consequently, unavailable for the most part to the root system of plants.

Again, it is important to realize that the relative abundance of Cs-137 to Sr-90 in fallout is about 1.6 to 1. The Cs-137 to Sr-90 ratio in irradiated fuel is about 1 to 1. The

Cs-137 to Sr-90 ratio in primary coolant water is commonly about 1000 to 1 and the ratio of Cs-137 to Sr-90 in the liquid effluents of pressurized water cooled reactors ranges between about 10 to 1 and 5000 to 1.

It is similarly important to realize that dairy cattle in Western Pennsylvania are maintained on a regimen of stored feed from October to May rather than on pasturage. This situation leads to a sizable lag in the observation of radioactive material in milk following its deposition on silage.

With these well-understood phenomena and conditions in mind the milk data for 1971 and the first quarter of 1972, as originally reported, were examined. For the sampling period for the first few months of 1971 when the dairy cattle were likely to be sustained on feed materials produced in the 1970 growing season, the average Sr-90 concentration exceeded the Cs-137 concentration by about 2 to 1. This might suggest the presence of very old fallout. It also suggests that the soil producing the stored feed was not reluctant in releasing stored Sr-90. Then, for the sampling period representing the grazing season the average Cs-137 concentration exceeded Sr-90 concentrations by a factor of less than 2 to 1, indicative of current fallout. It suggests also that the cattle grazed on vastly different soil from that which produced the preceeding crop of silage. Then, for the sampling period representing the return to stored feed (produced in the 1971 growing season), the Cs-137 averages generally exceeded the Sr-90 averages. This suggests that the silage was grown on a third kind of soil; or else, significant airborne releases occurred at Shippingport in the summer of 1971.

Two conclusions, then, are available. Either the reactor had unreported releases in the summer of 1971, or the original data is unreliable. (See opinion on Sr-90 data; see section on milkborne I-131 analysis for opinion on data for gamma-emitters (Cs-137)).

If the reliability of the original data is assumed, substantial difficulties are encountered. If coolant leaks had occurred, materials in addition to Cs-137 and Sr-90 should have been observed. Operating history of other pressurized water reactors indicates the release in liquid effluent of Cs-134 is about equal to that of Cs-137 and the release of Sr-89 is commonly greater than that of Sr-90. Iodine-131 in particular should have been observed if the samples were analyzed within a reasonable period of time. Since I-131 was not observed nor was any other short-lived material, simultaneously with the increased milkborne Sr-90 concentrations in early 1971, either the reliability of the original data, or the conclusion is questioned. The problem of interpretation of data at this late date is compounded by the fact that data collected and reported by NUS were not interrelated and evaluated at the time and insufficient effort was made to look for and examine ratios of the radionuclides in the environment and compare them with those observed in the liquid and gaseous releases.

The variation of the milkborne Sr-90 with time, when considered alone, is grounds for questioning the original data. The decline of average milkborne Sr-90 concentrations from over 20 pCi/l to less than 10 pCi/l over a time period of about 100 days is somewhat atypical.

It is concluded, then, that the original NUS data for milkborne Sr-90 and other radionuclides are not a reliable or sufficient basis upon which to sustain an allegation of unreported atmospheric releases for the period in question. Revised data supplied by NUS support this conclusion, provided that the retrieved samples were indeed typical of the earlier samples.

Iodine-131 Concentrations in Milk

As indicated in the foregoing section the sampling of fresh fluid milk is a valuable component of an environmental radiological surveillance program. In addition to the radioisotopes of strontium (Sr-90 and Sr-89), iodine-131 (I-131), barium-lanthanum-140 (Ba-La-140), and cesium-137 (Cs-137) are known to find their way into cows milk.

The NUS sampling program conducted in the environs of BVPS included analysis for I-131, Ba-La-140, and Cs-137 in fresh fluid milk. The results of these milk analyses for the first quarter of 1972 indicated the intermittent presence of I-131 and Ba-La-140 against the routine presence of Cs-137 and the isotopes of strontium as discussed previously. The presence of I-131 and Ba-La-140, since these materials are very short-lived (days) when compared to Sr-90 and Cs-137 (years), would suggest the recent release of fresh fission products. The more biologically signficant of these short-lived fission products is I-131.

Since no hospitals or other users of I-131 were identified in the site environs, three possible sources of this material were considered. These sources include fresh fallout from weapons tests, Shippingport releases, and analytic error.

Radioiodine is introduced into the lower atmosphere (troposphere) and, thence, into milk supplies by weapons tests of devices of 100 kilotons or less. Weapons tests for that range device were conducted on November 18, 1971 and January 7, 1972 by the Peoples Republic of China at the Lop Nor test site. The transit time of the fallout cloud to the greater Pittsburgh area is about seven days with a subsequent plume pass occurring about three weeks later. It would appear, then, that I-131 from the November 18, 1971 shot may have been observable in some of the milk samples taken in later November 1971 with lesser quantities observable in the late December samples. The reverse observations occurred, that is I-131 was not observed on the first cloud pass but it was observed on the second pass. With regard to the January 7, 1972 tests, I-131 might have been observable in some of the milk samples taken at the end of January with lesser quantities possibly observed in samples taken at the end of February. With one exception, the reverse was again true, that is higher concentrations were recorded after the second pass than were recorded after the first pass. This pattern within the study is unusual. In any case this pattern suggests that the NUS measured values were not likely to be related to these nuclear weapons tests.

At the same time it is notable that neither I-131 nor Ba-La-140 were observed in fresh milk in the Pasteurized Milk Network for the Eastern United States during either of these episodes.

Radiological Health workers have been observing the behavior of weapons debris fallout for almost 20 years. Consequently, several interrelationships and patterns of weapons-produced fission product behavior are well-understood. One of these principles is the understanding that the observation of short-lived fallout materials such as I-131 and Ba-La-140 is accompanied by a gradual increase of the more persistent species Sr-90 and Cs-137. A study of the original NUS data shows steady and/or declining concentrations of persistent isotopes following observation of new I-131. This observation is not consistent with past weapons fallout behaviors.

Scrutiny of air particulate sampling data for the periods representative of weapons-test plume arrival time should bear on the validity of the reported I-131 observations in milk.

The arrival of plumes should be accompanied by substantial increases in air particulate concentrations; up to several picocuries per cubic meter for the I-131 concentrations reported. These prerequisite rises in air particulate activity were not observed. It is highly unlikely, then, that the reported milkborne I-131 concentrations could be due to weapons-test fallout.

The second potential source of this milkborne radioactivity that was considered is the Shippingport Atomic Power Station. Iodine-131 is abundantly produced in the core of a reactor. Iodine isotopes escape from the core to the coolant water by diffusion through the cladding and through small cladding failures. Records of airborne releases from the plant by way of the gaseous waste disposal system indicate that no releases were made for all of 1971, and for January and February 1972. A review of the operating experience of other pressurized water reactors indicate that the annual release of I-131 is in the millicurie range.

An alternate route for the escape of airborne radioactive material is by way of the continuous purge of the primary containment. It was postulated that leaks from the primary coolant system onto the floor of the containment structure could give rise to airborne releases which the gaseous waste disposal system could not see. Using records of the concentration of radioactive materials in the primary coolant during the time in question several organizations calculated the quantity of coolant that would have to have leaked from the primary coolant system to yield enough I-131 in the containment purge to lead to the concentrations of I-131 reported to be in local milk. It was found that the leak rate would need to have been so large so as to suggest a major system failure. A major failure is not evidenced in the operating records.

The third possible source of the milkborne I-131 observations is analytic error.

The radioanalytic technique commonly used for the analysis of gamma-emitting radioisotopes including I-131, is gamma spectrum analysis. This technique involves little or no sample preparation. (This is in contrast to analytic methods used for the isotopes of strontium which required chemical separation of the material from the sample prior to using radiation detection techniques.) In gamma spectrum analysis, the data are generally presented by the detection system in a digital form and/or a graphic form. A spectrum shows peaks at specific locations which allows radioisotopes identification. The size of a peak is indicative of the quantity of material in the sample. All gamma emitters present in the sample are detected simultaneously.

The quantities of radioactive materials in environmental samples are generally quite small. This situation demands sophisticated mathematical processes for the reliable resolution of gamma spectra. The use of computer routines is very common in the reduction of spectral data.

Although much concern was expressed over the appearance of I-131 in the milk samples gathered in the first quarter of 1972, it is notable that Ba-La-140, a short-lived gamma emitter, also appeared intermittently. It is also notable that the milkborne Cs-137 data was very irregular throughout the five quarters represented in the original report. Cesium-137 is a long-lived gamma emitter. The values for Cs-137 concentration, when observed, were higher than those reported elsewhere.

Since I-131 is a short-lived material, it was not possible for NUS to use the data verification processes used in the verification of strontium data for soil and milk. The only recourse was the reexamination of the milk spectra and the computer routines used to resolve the spectra.

NUS since has stated that the computer routines used to generate the originally reported data were not proper. The use of alternate routines, believed to be more suitable, resulted in a downward revision of milkborne iodine data. An added result of the application of the new program(s) was the virtual disappearance of Ba-La-140 from the milk data, and a change in the Cs-137 data. The changes in the Cs-137 resulted in values approximating those reported elsewhere.

The presence of I-131 is still reported in the revised milk data for the first quarter of 1972. These I-131 data remain in conflict, however, with the facts that that radionuclide was not reported as present in any milk surveillance effort in the Eastern United States and that the Shippingport's coolant inventory of I-131 was still much too low to lead to revised milk concentrations.

It is of major importance to note that during the time of year that is represented in the first quarter of 1972 data, dairy cattle are not at pasture. Their regimen consists of stored feed produced during the preceding growing season. The water supplies for these herds is not from surface sources. It is difficult to postulate the mode of uptake of I-131 by the herds in question, if, in fact, the I-131 data for milk are accurate.

Ohio River Sediment Data

Data reflecting radioactivity concentrations in bottom sediments in the Ohio River were used to reach the alleged conclusion that Shippingport has experienced unreported releases of liquid radioactive waste to the Ohio River.

The sets of bottom sediment data used to reach that conclusion included data from a study conducted by the University of Pittsburgh School of Public Health (Shapiro) with samples collected in 1959-1960, and, data generated by NUS as a part of the preoperational surveillance program for BVPS in 1971.

The bases of comparison used to reach the conclusion that Shippingport had had substantial unreported liquid releases were the lowest value reported in the University study in 1959-1960 as a base line, and the values reported by NUS as reflecting current (1971-72) conditions, with the difference being attributed to substantial unreported releases from Shippingport. The differences in bottom sediment radioactivity concentration between the cited data were substantial. The data used for the comparison were in each case, values for gross beta activity, that is, with no qualification as to types of radioactive materials contributing to the activity.

The sampling of bottom sediments of rivers which receive liquid radioeffluents is useful in interpreting liquid radwaste source data and ambient concentrations of radioactivity in surface waters. That medium, bottom sediments, is, however, of no direct use in assessing dose to people.

It is extremely important that samples of bottom sediment undergo at least semiqualitative analysis for the identification of contributing radioactive materials. Otherwise (using gross analysis alone) the data are of little value. Semiqualitative analysis provides the investigator with the tools needed to associate the observed activity with the facility under investigation, weapons fallout, other facilities upstream and natural radioactivity.

The first study entitled Radioactive Waste Disposal in the Upper Ohio River Basin was conducted by the University of Pittsburgh under the direction of Dr. Maurice Shapiro of the School of Public Health. Samples were collected at four locations in the river during 1959-60. The objective of the investigation was to measure the effect of the discharge of radioactive waste on a river system. The reactor had been operating for three to four years at the time.

Several impediments are evident in the Shapiro study. Consequently, care must be exercised in using the data. All data generated by that study are given in terms of gross activity. None of the radioactive components in the samples are identified. At the time of the study, however, sophisticated identification techniques were not generally available. Another consideration to be taken in using the data is the fact that the period during which the samples were taken was a time of substantial fallout resulting from U.S. and USSR atmospheric weapons testing prior to the establishment of the moratorium in 1958. The contribution of fallout debris to sediment concentrations would have been enormous, so enormous, in fact as to mask the contribution from Shippingport. Even if the investigation had been conducted with analytic techniques available today, it would have been well-nigh impossible to see a Shippingport contribution. A third difficulty with that investigation was the unpatterned schedule of field sampling activities for bottom sediment. Seldom were samples collected on the same day at all sampling points. It would appear that essentially simultaneous scheduling would be desirable to find trends and patterns with the accuracy needed to satisfy the objectives of this investigation. This is especially true of water samples and to a lesser extent true of samples of sediment. A fourth difficulty with the investigation was the wide range in the reported bottom sediment concentrations, from fractional picocuries per gram to over a hundred picocuries per gram. The lower values, in particular, might be questioned, since natural radioactivity, along, normally would have exceeded the low values reported. A fifth difficulty is the absence of consideration of counting statistics. Accordingly, it becomes difficult to interpret the results of this early study in light of current knowledge.

The NUS report for BVPS provided the second set of Ohio River sediment sampling data, which had been compared against the Shapiro data. This bottom sediment sampling program sampled 3 to 5 locations quarterly. All locations were sampled on the same day. The data under discussion reflected 1971 sampling. The NUS data were expressed in terms of gross activity and concentration of gamma emitters. In each case, the natural radioisotope potassium-40 accounted for most of the observed gross radioactivity.

The argument presented by some investigators, that a comparison of NUS data against the lowest value reported by Shapiro leads to the conclusion that Shippingport had experienced unreported releases in 1971, is without merit. The argument presumes that the low concentration reported by Shapiro (about 2 pCi/g) is representative of background, when it is not. The average potassium-40 component alone would be expected to approximate 10 pCi/g of sediment, not to mention additional activity due to natural uranium and thorium. It is doubtful whether the Shapiro data, even if obtained with the accuracy possible with modern instruments, would be useful in providing baseline information for current studies in view of the quantity of weapons fallout activity in the environment at the time the study was conducted.

Department of Environmental Resources Water Quality Network Data

Department of Environmental Resources (DER) Water Quality Network (WQN) data has been used to support the allegation that Shippingport had discharged substantial unreported quantities of radioactive materials to the Ohio River. The allegation singled out the years 1964-65 and 1970.

The WQN is operated by DER with the objective of establishing the presence, trends, and variability of a number of materials including radioactivity in the surface waters of the Commonwealth. Grab samples are collected quarterly. Radioassay is limited to gross analysis. Attempts are not made to follow a parcel of water in its journey from tributary to main streams. Variations in concentrations cannot, therefore, be easily attributed to a particular source of pollution. The program objective is to observe variations in water quality, not to monitor operations of sources.

The methodology whereby the subject allegation is developed is fragile. The method adopted by the investigator took the gross activity observed in a grab sample taken at a location miles upstream of a given source and compared it with the gross activity observed in a grab sample taken miles downstream of a source, took the difference and multiplied by river flow. (The samples may not even have been taken the same day.) The method assumed that the difference in concentrations prevailed and river flow rate prevailed throughout the calendar quarter. The result was then express as "excess" curies.

These allegations are based upon a comparison of East Liverpool, Ohio data with data from upstream locations, the Allegheny River at Kittanning for the 1964-65 period and two locations, the Allegheny River at Natrona and the Monongahela River at Greensboro for the 1970 results. The upstream locations chosen for the two time periods in question were the lowest of all the upstream locations. If the Allegheny at Kittanning had been used as the baseline in the second comparisons, one could assume that Shippingport actually reduced the level of radioactivity in the Ohio River. Other stations at other times would also show this type of result. Not only is the allegation based upon selected data, the basic assumption that a grab sample taken at any location can be directly correlated with any other location is scientifically unsound since the system was not designed for such direct comparisons.

A more complete review of the data for Southwestern Pennsylvania shows that in every sampling quarter from 1964 through 1972, there are samples collected upstream from Shippingport which were either equal to or surpassed the levels of radioactivity at East Liverpool. By manipulating available data one can come to a variety of conclusions.

Federal Environmental Radiological Surveillance at Shippingport - 1973

In early 1973, two separate agencies of the federal government conducted independent surveillance activities in the environs of the Shippingport Atomic Power Station. These agencies were the U.S. Atomic Energy Commission (AEC) and the U. S. Environmental Protection Agency (EPA).

The AEC activities consisted of an aerial environmental survey of the environs of Shippingport. The survey documented ambient gamma radiation levels, corrected for altitude, and provided for the identification of gamma emitting radionuclides.

The reactor was operating full power at the time of the aerial survey.

The results of the aerial survey indicated that the gamma radiation level in the environs of Shippingport was to the order of 4 to 12 μR/hr., including a cosmic radiation component of 3.6 μR/hr.

The values observed were comparable to ambient gamma levels and Cs-137 components observed eslewhere in the country, using identical detection techniques.

The EPA activities, which employed environmental media quite different from the AEC effort, began after the completion of the AEC activities. Health physicists from the EPA laboratory in Montgomery, Alabama, sampled milk, silage, soil, and ambient radiation. That organization also sampled a variety of media in the Shippingport reactor internals.

The findings of the EPA effort indicated that the excessive presence of persistent radionuclides (Sr-90 and Cs-137) in the environment (soil, milk, ambient gamma) was not evident. It was also reported that the coolant inventory was similar to that reported by the operator of Shippingport.

The results of these independent federal investigations, suggest then, that if persistent radioisotopes were emitted by Shippingport in the past, these materials are not now as evident as would be expected.

Pasteurized Milk Network Data

The Pennsylvania Department of Environmental Resources (DER) conducts milk monitoring programs for radioactivity in several major cities in the Commonwealth. The samples collected are composites of milk by distributor, so as to represent the average milk consumption for the city of interest. No effort is made to composite by geographic area of milk production. Routine analyses include assay for Sr-90, I-131, Ba-La-140 and Cs-137.

If the alleged 20 per cent excess Sr-90 in Pittsburgh milk is due to the operations at Shippingport, one would expect rather high concentrations of Sr-90 in milk produced in Beaver County, and very high concentrations in milk produced close to the site. Concentrations of Sr-90 in milk produced in Beaver County of the magnitude necessary to produce the 20 per cent excess were not observed by any surveillance activity. The apparent excess cannot easily be attributed to Shippingport operations.

Care must be exercised in attempts to draw conclusions based on the ratios between an observed value and the average of many similar observations. The very concept of "average" implies a range of values. For observations above the average there must be equal and balancing observations below the average.

Other cities in the pasturized milk network were also higher than the national average over many years. These include, but are not limited to, New Orleans, Charleston, S.C., Minneapolis, Louisville, Minot, S.D. and others. New York City is a typical example of wide variations from the average to 50 per cent above the average. Pittsburgh is not alone in being above average. It is agreed that additional studies should be carried out to determine the real cause for this phenomonon.

General Comments Concerning Environmental Monitoring and the Shippingport Beaver Valley Program

Much of the testimony centered around the monitoring of radioactivity in the vicinity of the site. The question is whether the monitoring program around the site was adequate to determine if such releases did reach the environment outside the plant.

Environmental monitoring programs serve as a useful tool to evaluate effectiveness of in-plant monitoring programs, the environmental pathways to man, population radiation exposure, and the ultimate fate of radioactivity released to the environment. The design of the program should take into consideration the source of the radioactivity, the types of radioactivity which could possible be released, and other environmental sources of radioactivity. This in particular would include consideration of fallout radioactivity, and of other sources of man-made radioactivity in the general vicinity such as hospitals, other power reactors and industry.

It is very important that the objectives of any environmental monitoring program be well established and understood early in the design and development of the program. These criteria have substantial effect on the selection of sampled media, sampling frequency, radioanalytic method selection and sensitivity. The criteria also bear heavily on the routine for data review and evaluation.

Substantial evidence is available, to indicate that these fundamentals were not built into the radiological monitoring program at BVPS. In addition, several aspects of the BVPS problem may well be generic.

A fundamental difficulty in the subject controversy is the fact that the data were not subjected to timely review either by health physicists of NUS or Duquesne Light Company (Shippingport). By the time the data were made public, any opportunity to validate the date was lost.

It is very important that data be scrutinized on a timely basis. This implies a rapid turn-around time for sample analysis. The matter of adequate turn-around time is mandated if, indeed, these programs are to serve the purpose of source control verification. If long turn-around times, to the order of a year as in this case, are a universal condition, then this early review problem is, indeed, real and generic. It would seem almost self-evident that there be a constant feedback between the data collected and the environmental sampling program to assure a sensitive and meaningful correlation between what is reported in plant effluent samples and what is measured in the ecosystem.

Abundant evidence is available to support a contention that NUS had not deployed a proper quality assurance program for the methods used to analyze environmental samples including the failure to provide control samples. This absence of a proper quality assurance program compounded the failure to provide timely review so as to produce a mass of faulty data. This difficulty with quality assurance is also likely to be generic. It is becoming abundantly clear that some national agency should assume the responsibility of providing calibration standards traceable to the U.S. Bureau of Standards to any organization engaged in low level radioassay. That same agency should develop and maintain interlaboratory comparison exercises for significant environmental vectors for radionuclides peculiar to that vector. That same agency should maintain a laboratory certification program. Any organization, then, be it consultant, government, university, utility, or environmental group, that seeks to publish radiological environmental surveillance data for the purpose of documenting the radiation environment, must bear an up-to-date certification as to their competency in generating the data.

Although substantial fault can be attributed to the ineptness of NUS in this matter, Duquesne Light Company, who bought the data, bears even greater blame. The basis for this blame is in their failure to have established a proper Health Physics program early in the BVPS project. This problem is also likely to be generic. The early establishment of a Health Physics program was particularly important in this project due to the presence of a source (Shippingport) in the immediate site environs. It is obvious, that, if the irregular data provided by NUS was reviewed at all by Duquesne Light Company, the reviewer did not grasp their significance.

The matter of dual occupancy at the site added to the confusion. The Shippingport nuclear steam supply system is owned by the U.S. Atomic Energy Commission, Division of Naval Reactors. The conventional end of the plant, from the turbines on out, is owned by Duquesne Light Company. Next door to Shippingport are the BVPS owned by Duquesne Light Company. Duquesne Light Company operates or will operate both facilities. The U.S. Atomic Energy Commission Dictorate of Regulatory Operations regulates BVPS, but not Shippingport. This whole scene devolved into a situation where AEC (Regulatory) was unaware of Shippingport activities, Naval Reactors was not interested in BVPS monitoring data, Duquesne Light operations at Shippingport were unaware of the BVPS activities and vice versa. It is clear that much more intra- and inter-agency communications is in order. If the principles of apartheid are continued at the site, particularly between the two entities of the AEC, it is possible that the outcome of the next lack of communication will be less innocuous.

For matters affecting the environment it is prudent that all facilities on a reactor site be considered simultaneously, without regard to the licensing status of individual facilities.

The absence of environmental surveillance activities by the Commonwealth Department of Environmental Resources (DER) at the Shippingport-BVPS site served the interests of no one. Very probably, had DER been conducting only a modest program in the site environs, this controversy would not have evolved to its awesome proportions. Independent monitoring by State agencies is valuable in supporting or refuting the findings of other organizations. This independent activity would assure early response in calling attention to and demanding an explanation of irregularities and anomalous data.

It is prudent, then, that DER develop the resources to carry out proper independent radiological environmental surveillance activities at this site and every other nuclear facility in the Commonwealth. The programs should include verification of source terms as well as off-site surveillance. The costs associated with this sort of activity are expected to be rather substantial, particularly in light of the number of facilities in need of this State activity.

A committment by the Commonwealth to prepare itself to deal safely with the nuclear age is strongly indicated.

Testimony presented at the Committee's hearings stated that with the low releases from normal operation of a plant like Shippingport, a great deal of the monitoring done is a waste of time and money. One can agree with this statement and at the same time consider that better surveillance of the environment would be possible. To reassure the public, measurements capable of detecting large releases of the shorter lived radionuclides as well as a significant rise in long-lived radionuclides outside the plant boundaries are necessary, as well as is a continuous check on the effluent pathways (water, stack gases, etc.) with continuous surveillance of particularly important radionuclides such as C-60, I-131, Sr-90 and Sr-89, Cs-134 and Cs-137, and the alpha-emitters. It is especially important to be able to assure the public that essentially no alpha-emitting radionuclides are being released to the air or water from the plant. Methods must be devised which would provide this reassurance without requiring a burdensome number of analyses. The utilities and State and Federal agencies should carefully evaluate what needs to be measured in order to define the radiation exposures to the public from all kinds of releases from these plants. Some current monitoring practices may be unnecessary, but others must be developed and continued for the lifetime of the plants. There must be constant feedback between the analyses of data from the source and from the environment and the types of data collected.

CONCLUSIONS

Based upon the analyses performed and the information presented, the Committee finds no substantive evidence that radioactive material released from the Shippingport nuclear power plant have been significantly greater than those reported by the operators of the plant or allowed under Commonwealth or Federal rules and regulations. However, the lack of an adequate and comprehensive off-site monitoring program around Shippingport during its years of operation precludes accurate verification of the published data on plant releases. The high levels of Sr-90 in milk and of Sr-90 and Cs-137 in total diets of Pittsburgh residents as recorded in Federal network studies remain unexplained.

Based on the findings of environmental surveillance activities of two distinct Federal agencies and DER in 1973, the levels of persistent fission products in the environment provided no evidence to suggest substantial unreported releases from Shippingport.

The NUS pre-operational environmental monitoring program for the Beaver Valley Power Stations reported a number of irregular levels of radioactivity in samples during 1971 and 1972. The findings were subsequently reanalyzed and the majority discounted by NUS Corporation. Careful examination of the original data alone frequently led to suspicions as to its quality. NUS also retrieved some previous samples for intercomparisons with other laboratories. If the retrieved samples were indeed typical of earlier samples, the reanalysis confirmed that NUS was in error in its earlier data. It is difficult to understand why at this late date NUS now finds its early reported high values were false when several different and independent types of analyses were involved.

Analyses of Pennsylvania Department of Environmental Resources milk monitoring data and water quality network data did not support the allegation that Shippingport releases were excessive; neither do they preclude the possibility of excessive releases at an earlier date. This is an indication that the DER program was not adequate to determine certain kinds of environmental releases from Shippingport.

Because of problems inherent in the dual role of the Atomic Energy Commission in this particular incident, i.e., being the owner of the Shippingport plant and regulator of the Beaver Valley plants, the Committee supports federal legislation separating the regulatory and developmental components of the Atomic Energy Commission.

EVALUATION OF THE ALLEGED HEALTH EFFECTS

The allegations appraised by the following epidemiologic analysis may be paraphrased as follows:

> There is a direct cause-and-effect relationship between radioactive material released to the environment from the Shippingport Nuclear Reactor and a significant increase in the rates for infant mortality, and mortality due to heart disease and cancers (including leukemia and lung cancer) within the population of Aliquippa and other nearby communities.

Epidemiologic Approach

In order to provide sufficient scientific evidence to support or refute the allegations, one must: (1) establish firm statistical evidence relating the allegedly high mortality rates to the implicated time-geographic context; (2) determine if the alleged or reported releases of radioactive material from Shippingport could be implicated in the pattern of mortality; (3) rule out the possibilities of other causes which might have been responsible for the allegedly high mortality rates. In other words at lease three fundamental questions must be answered;

> First - Is it true that the mortality rates under consideration within the time and space context being implicated are significantly greater than would be expected?
>
> Second - If the answer to the first question is affirmative, then, is it true that the amount and timing of the alleged release of radioactive materials into the environment are consistent with the observed excess mortality?
>
> Third - Have the effects of all other factors which are either known or suspected to be capable of increasing the level of mortality in question been accounted for?

Analyses presented in this Section are primarily focused on the first and third lines of inquiry. To answer the first question, two different types of observations were made, historical and cross-sectional.

In the historical analysis, an attempt was made to determine whether or not the pattern of change in death rate within the population of Aliquippa was unusual, i.e.. significantly different from the pattern of change in mortality that would be expected in comparison with the experiences of other similar populations (except for the presence of a nuclear reactor) and of the Commonwealth of Pennsylvania as a whole. If radioactive materials were in fact released to the environment in sufficient quantity. a significantly elevated mortality rate in the affected population may be observed in due time following initial exposure. For this analysis, an 11-year period from 1961 through 1971 was considered; data used for this analysis were derived from the vital statistics records compiled routinely by the Pennsylvania Department of Health and from some of the census data collected by the U.S. Census Bureau.

In the cross-sectional analysis. a comparison was made between the level of mortality in Aliquippa for a given year during the 1961-71 period and the level of mortality in a number of other similar communities (except for the presence of a nuclear reactor) and the Commonwealth of Pennsylvania as a whole for the same given year. If the allegations were supported, the mortality rate in Aliquippa would be significantly higher than that in other similar communities selected for comparison. Data used for this analysis also covered the same 11-year period.

In addition, an attempt was made to determine if there is an epidemiologic evidence for a "dose-response" relationship between radiation and mortality. For this purpose, the rate of mortality was computed for different populations as delineated by approximate distance from the Shippingport nuclear reactor, i.e., within 5 miles, between 5 and 10 miles, and beyond 10 miles. Based on the potential risk by means of contaminated water in the environment, an attempt was also made to evaluate if there is a significant difference in mortality between "on-river" communities and "off-river" communities.

Since it is known or suspected that certain diseases or conditions can be induced by ionizing radiation, a further investigation was made of specific causes of death among both infants and adults. Specifically, some detailed analyses were made of leukemia, cancer of the lung, cancer of the bone, and neoplasms of the lymphatic and hematopoietic tissues as well as congenital anomalies in infants and the rate of fetal deaths.

Methodological and Technical Problems

There were many difficult methodological and technical problems in conducting an epidemiological investigation of this type. Five such problems were particularly important and should be recognized.

First - Mortality rates for small populations particularly when relatively infrequent diseases and conditions are considered, fluctuate rather markedly from year to year and from place to place There fluctuations may or may not be attributable to any real changes or differences in the mortality being investigated.

Second - No systematic or accurate clinical (morbidity) data were available on the local populations being implicated. Thus, it was not possible to evaluate the nature and extent of relatively subtle and chronic insidious effects of ionizing radiation which might have existed.

Third - Only mortality data reported by certifying physicians or coroners in death certificates were available. Data recorded in death certificates are often incomplete and subject to qualification with respect to diagnosis. Furthermore, mortality rates and/or causes of death are influenced by many different factors, host and environmental; this is particularly true in chronic, nonspecific diseases. For example, in addition to three basic demographic factors (age, sex and race), socio-economic and cultural characteristics of the population and any one or any combination of various physical environmental contaminants affect mortality risks. While some of these influences, such as race, sex and age, can be taken into account in the course of statistical analysis (e.g., standardization of rates; matching), it was not possible to make such adjustments because of the lack of data.

Fourth - Mortality rates are influence by the diagnosis of a disease or condition and by the reporting practice. For reasons not completely understood at present, there is a rather systematic bias in reporting vital events with respect to the place of residence. Specifically, relatively more deaths, and to some extent more births, are reported to cities and boroughs than should be; in other words, such events are less likely to be recorded in or allocated to townships than should be. This biased reporting practice would overestimate the rate of mortality for more urban areas and, at the same time, underestimate the rate for more rural areas.

Fifth - No information was available with respect to the latent period in leukemogenesis and carcinogenesis, i.e., the time from initial exposure to an environmental agent (radiation) to the initial recognition of clinical symptoms (cancer). Often, there is also a certain time lag between initial symptoms and actual diagnosis. The latent period must be properly incorporated into the length of survival when mortality data are used for analysis. In-depth analyses of all these data, however, were clearly beyond the scope of our capability in terms of time, staff and other resources available. Since no mortality data were available beyond 1971, it is obvious that no effects could be detected relative to cancer mortality rates from alleged releases which occurred in 1971.

Limitation on Radiation Data

One of the crucial variables in a proper study would be the amount of ionizing radiation released from the Shippingport nuclear reactor. However, the radiation data which were available are incomplete and subject to qualification with respect to timing, quality and quantity. No concrete data existed as to how many individuals of the local population were exposed to radiation, nor was there accurate information regarding the environmental pathways of exposure. Accurate information of this type is essential, but such information did not exist and could not be ascertained.

Results of Epidemiologic Analyses

Infant and Related Mortalities
(See Appendix A, Tables 1 through 13)

Based on the available biostatistical data and from the results of reasonably detailed epidemiological analyses of such data, it cannot be determined whether the infant mortality rate in Aliquippa is or is not higher than would be expected based upon data from the rest of the State (See Tables 6b, 6c and 7). It was found that the relatively large proportions of nonwhite births, therapeutic abortions and illegitimate births in Aliquippa can help explain the observed relatively high levels of fetal (stillbirth) (See Tables 5c and 5f), neonatal (first 28 days) (See Tables 3 and 5b), and infant (first 12 months) mortalities. However, when white infants are considered separately, the observed death rate for Aliquippa was considerably higher than would be expected. While this is not completely explainable, the same phenomenon did exist in other similar urban communities (See Table 12). To some extent, inaccurate reporting of residence by white parents who live near the city lines may be responsible.

There is no clear evidence to indicate that the infant mortality rate within the 5-mile area from Shippingport is higher than would be expected (See Table 8) nor is there sufficient evidence to suggest that the rate in communities along the Ohio River is higher than would be expected (See Table 9). An extensive analysis has failed to find any unusual pattern of specific causes of death (See Tables 10a, 10b and 11), including congenital anomalies, among the infants reported to have resided in Aliquippa or in its surrounding communities.

Cancer and Related Mortalities
(See Tables 14 through 23b)

Our analyses have failed to find any substantial evidence that the overall cancer death rate for the area within five miles of Shippingport (See Table 14) or for the "on-river" communities (See Table 17) was higher than would be expected.

The death rate due to cancer of the bone, connective tissues, skin, and breast for the same area was also found to be similar to the State average (See Table 15).

Midland, immediately continguous to Shippingport, had a 1961-71 average cancer death rate, which was higher than the State as a whole (See Table 18). However, since the Midland population was older than the State population, relatively more cancer deaths may be expected. Furthermore, different cancers are caused by different environmental and host factors Therefore, analysis of cancers of all forms together is, at best, suggestive of the fact that further data and further research are needed when possible radiation effects are considered. Cancer of the lung and bronchus can be caused by ionizing radiation. However, the rate of lung cancer death in Midland was not unusual. The temporal pattern of change in the lung cancer death rate seemed to have fluctuated randomly and was not consistent with the expected pattern of radiogenic lung cancer as reported by other investigators.

The leukemia death rate for the 5-mile area was not significantly different from the State average, nor was there any systematic pattern by distance from Shippingport (Table 16). The death rate due to other neoplasms of the lymphatic and hemotopoietic tissue was slightly higher than the State average for the 5-mile area (See Table 16) and for the "on-river" communities (See Table 19). The average 1961-1971 level of leukemia death rate and that of other neoplasms of the lymphatic and hemotopoietic tissue in Midland were both within normal ranges (See Table 20). Annual leukemia death rates for the 1961-1971 period fluctuated considerably in Midland, but these rates are based on only one or two cases in a small base population.

For the 1961-1971 period there was only a slight difference in leukemia death rates between Beaver Councy and Pennsylvania as a whole, the difference being due solely to slightly higher rates for lymphatic leukemia and Hodgkin's disease (See Table 21). When Aliquippa Borough was considered separately the average death rate for 1969-71 leukemia and other neoplasms of the lymphatic and hematopoietic tissue was considerably higher than the State average (See Table 21). However, a closer examination of individual death certificates and a separate analysis on annual leukemia death rates indicated that (1) the leukemia death rate in Aliquippa was not significantly different from the State average in any single year during the entire 1961-1971 period (See Table 23b); (2) the number of leukemia deaths by specific cell type was only one or two per year on the average; and (3) deaths due to other neoplasms of the lymphatic and hematopoietic tissues was also very small in number and included a relatively large proportion of unspecified neoplasms and myelofibrosis (See Table 21). A more definitive pathological evaluation of these data is indicated.

Cause-Specific Mortality
(See Tables 24 and 25)

The overall cause-specific mortality in Aliquippa showed, on the surface, a rather unusual pattern as compared with that for the State as a whole (See Table 24). However, when Aliquippa data were compared with data for eight other communities in Pennsylvania, similar in population size and racial composition, it became clear that Aliquippa was not atypical as far as major causes of death (See Table 25).

Conclusions

Based upon available mortality data, no sufficient evidence was found to support the allegations, but neither can they be refuted from the available data. It cannot be concluded from the evidence presented thus far that the Shippingport nuclear reactor was responsible for the observed mortality pattern in Aliquippa and in its vicinity; the pattern is not different from what might otherwise be expected. These analyses, however, have not ruled out the possibility of more subtle effects of radiation on human health, which are difficult to detect with the currently available techniques. This difficulty rests upon two major problems: (1) It is extremely difficult to ascertain accurate measure of low dose radiation absorbed by local residents and to differentiate the exact source of such radiation. (2) It is virtually impossible to clearly delineate the influence of multiple factors which affect human health.

It should be noted that epidemiologic analyses by themselves usually do not establish a definite "cause-and-effect" relationship, because such analyses are based on the theory of statistical probability of an event without delineating the reasons for a given statistical association. Positive eipdemiologic evidence, if found, must be supplemented by other evidence -- clinical and experimental -- before final conclusions can be drawn. Also, in a field epidemiologic investigation, such as presented here, the totality of all the results ascertained from many different but related analyses is of prime importance in formulating conclusions.

In short, the allegations were based on unsubstantiated radiation data and the application of improper methods of analyzing the existing, but inaccurate, health data.

No significant health effects, including infant mortality, radiogenic cancers, and major chronic diseases, have been detected in Aliquippa or Beaver County that cannot be explained at least to some extent by reporting errors or other well-known sociological and other characteristics of the population.

Although the allegations cannot be substantiated from the available data, neither can they be completely ruled out. Certain anomalies in the data remain unexplained.

The public should be made aware that the reported data, environmental or health, are not without qualification. Improper application of such data in determining risks of any specific environmental hazards on health would not only be unjustified, but would be a disservice to the society. It is the responsibility of the public and private agencies which release such reports to assure their accuracy, particularly when significant public health issues are involved.

RECOMMENDATIONS

1. In order to determine the radiation exposure of the public, to determine compliance with applicable regulations, and to assure the citizens living near nuclear facilities of adequate protection from radiation exposure. the Commonwealth should immediately begin a comprehensive environmental radiation monitoring program in the vicinity of all nuclear reactors and other large facilities. If such a program had been in existence around Shippingport during the time period in question, the situation could have been resolved immediately.

2. A proper quality control program for environmental radiation monitoring programs must be initiated immediately. NUS Corporation, in claiming that the results were in error. cites mistakes in calibration, mistakes in computer codes, and error in thermoluminescent dosimetry data. If sampling methods, radiochemical separation techniques, and proper calibration procedures were established and maintained through inter-laboratory quality control procedures and regulated by the federal government, such errors would never have occurred or would have been discovered almost immediately. This recommendation is of vital importance if nuclear power plants are to be built throughout the United States. The environmental assessment of their operation must be adequately and accurately known so that proper decisions can be made on the future use of nuclear power.

3. Adequate health physics programs should be initiated at all nuclear power plants very early in the utility's entry into the nuclear field. The health physics program should oversee the operations of consultants environmental monitoring programs. The health physics supervisor should be relatively free to work with the appropriate federal and state agencies. She or he should be well qualified with training, background and experience of at leas the qualifications of an individual certified by the American Board of Health Physics.

4. With specific reference to the Beaver Valley and Shippingport plants the following recommendations are made:

a. That Duquesne Light Company establish an adequate monitoring and reporting program for all facilities on the site.

b. That the AEC Directorate of Regulatory Operations take over the regulatory authority for the Shippingport Atomic Power Station. This will end the duality in operations at the two facilities.

5. It is recommended that the government carry out comprehensive evaluation of radiation exposure of the public around nuclear facilities. Where the possibility of significant exposure exists, appropriate epidemiologic evaluation of the health of these populations should be undertaken.

6. Several long-range plans should also be developed and implemented:

a. Better Methods for Vital Statistics Registration and Reporting:

Both birth and death registration systems and methods of coding, analyzing, and reporting such data should be imporved with respect to the place of residence of each individual affected. A more accurate method of identifying the place of residence will enable better evaluation of mortality risks for different geographic areas and municipalities. More complete use of all available mortality data should be instituted by coding. analyzing, and reporting both the underlying and contributory causes of death which appear on death certificates. In addition, systematic recording on death certificates of data such as occupation and duration of residence, should enhance the capability of the State Health Department to provide useful information for future planning, management, and evaluation of mortality risks.

Mortality data being released annually by the State Health Department should include both crude (unadjusted) and standardized (adjusted for demographic and social factors) rates for different causes and years as well as for different geographic and political subdivisions, so that geographic differences or temporal changes in the rate might be more easily explainable. This is of particular importance in populations surrounding nuclear facilities.

b. Cancer Registry and/or Hospital and Ambulatory Care Data Systems:

Establishment of a centralized Statewide cancer registry (which may require new legislation making cancer a "reportable disease") and /or similar development of a systematic and comprehensive hospital and ambulatory care data system would be an essential means for proper evaluation and management of various health problems regardless of time or place within the Commonwealth of Pennsylvania.

APPENDIX A

PART I. DATA ON BIRTHS AND DEATHS DURING INFANCY, ALIQUIPPA, OTHER SELECTED COMMUNITIES, AND PENNSYLVANIA

Table 1. Births, Fetal Deaths, Neonatal Deaths, and Infant Deaths; and Fetal, Neonatal and Infant Death Rates for Aliquippa, Beaver County and Pennsylvania: 1971

Table 2a. Mother's Actual Place of Residence for Live Births Coded to Aliquippa, Pennsylvania, 1971

Table 2b. Mother's Actual Place of Residence for Infant Deaths Coded to Aliquippa, Pennsylvania, 1970 and 1971

Table 3. Original and Revised Numbers of Births, Fetal Deaths, Neonatal and Infant Deaths, and Fetal, Neonatal, and Infant Death Rates for Aliquippa Borough, Pennsylvania: 1971

Table 4. Live Births and Original and Revised Number of Infant Deaths in Aliquippa and Surrounding Communities: 1970 and 1971

Table 5a. Births, Fetal Deaths, Neonatal Deaths, Infant Deaths, and Deaths from Certain Diseases of Early Infancy: Aliquippa Borough, Beaver County, and Pennsylvania, 1961-1971

Table 5b. Rates for Live Births, Fetal Deaths, Neonatal Deaths, Infant Deaths and Deaths Due to Certain Diseases of Early Infancy: Aliquippa Borough, Beaver County, and Pennsylvania, 1961-1971

Table 5c. Original, Revised, and Expected Number of Deliveries, Fetal Deaths, and Fetal Death Rates: Aliquippa, 1971

Table 5d. Fetal Deaths by Cause and Race, Original and Revised Counts: Aliquippa, Pennsylvania, 1971

Table 5e. Fetal Deaths by Cause, Sex and Race, Mother's Place of Residence, and Place of Delivery: Aliquippa, Pennsylvania, 1971

Table 5f. Selected Causes of Fetal Deaths by Place of Delivery, Original and Revised Counts: Aliquippa, Pennsylvania, 1971

Table 6a. Selected Characteristics of Births: 1971

Table 6b. Original, Revised, and Expected Number of Infant Deaths and Infant Death Rate: Aliquippa, 1971

Table 6c. Observed and Expected Infant Deaths and Infant Death Rates: Pennsylvania, Aliquippa Borough, and Harrisburg City, 1964-1966

Table 7. Selected Characteristics of Births: Aliquippa Borough, Beaver County, and Pennsylvania, 1961-1971

Table 8. Infant Deaths, Number and Rate According to Distance from Shippingport, 1961-1971

Table 9. Live Births, Infant Deaths and Average Infant Mortality Rates for 1961-1971 Period in "On-River" Communities, Beaver County, Pennsylvania

Table 10a. Infant Deaths by Cause: Pennsylvania, Aliquippa and Surrounding Communities (Original and Revised Place of Residence), 1970-71

Table 10b. Infant Death Rates by Cause: Pennsylvania, Aliquippa and Surrounding Communities (Original and Revised Place of Residence), 1970-71

Table 11. Specific Causes of Death: Infant Deaths in Aliquippa (1970)

Table 12. Observed and Expected Infant Death Rates by Race for Selected Communities, Pennsylvania: 1961-1971 Average

TABLE 1: BIRTHS, FETAL DEATHS, NEONATAL DEATHS, AND INFANT DEATHS; AND FETAL, NEONATAL AND INFANT DEATH RATES FOR ALIQUIPPA, BEAVER COUNTY AND PENNSYLVANIA: 1971

Variables	Aliquippa	Beaver County	Pennsylvania
	Number		
Total deliveries	323	3,154	185,018
Live births	305	3,101	180,939
Still births	18	53	4,079
Neonatal deaths	9	54	2,548
Infant deaths	12	62	3,314
	Rate		
Fetal death rate1)	55.7	16.8	22.0
Neonatal death rate2)	29.5	17.4	14.1
Infant death rate3)	39.3	20.0	18.3

1) per 1,000 deliveries

2) per 1,000 live births

3) per 1,000 live births

Note: Data by "residence" as reported in Natality and Mortality Statistics: Pennsylvania, 1971, Department of Health. Available evidence indicates that, due to inconsistency in the original reporting of residence and place of death, this data are subject to qualification.

TABLE 2a: MOTHER'S ACTUAL PLACE OF RESIDENCE FOR LIVE BIRTHS CODED TO ALIQUIPPA, PENNSYLVANIA, 1971

Mother's Actual Residence	Number of Live Births
Aliquippa Borough(Definite)	287
Aliquippa Borough(Probably)*	14
Ambridge Borough(Definite)	2
Certificate not located	2
Total	305

* Includes five addresses on Brodhead Road, which divides Aliquippa and Hopewell Township; four addresses with P. O. Box numbers; and five addresses for which adequate information is lacking.

TABLE 2b: MOTHER'S ACTUAL PLACE OF RESIDENCE FOR INFANT DEATHS CODED TO ALIQUIPPA, PENNSYLVANIA, 1970 AND 1971

Mother's Actual Residence	Number of Infant Deaths	
	1970	1971
Aliquippa Borough	14	7
Hopewell Township	3	3
Center Township	-	1
Hanover Township	-	1
Total	17	12

Notes: All of the infants who died in 1970 were born in 1970. One of the twelve infants who died in 1971 was born in 1970 and in this case the actual place of residence of the mother, on both the live birth and death certificate, was Aliquippa Borough. In two of the three instances where place of residence was incorrectly coded on death certificates in 1970, the corresponding birth certificates were also incorrectly coded. In 1971, however, the birth certificates corresponding to the five incorrectly coded death certificates were correctly coded. The longest interval between birth and death was two days.

TABLE 3: ORIGINAL AND REVISED NUMBERS OF BIRTHS, FETAL DEATHS, NEONATAL AND INFANT DEATHS, AND FETAL, NEONATAL, AND INFANT DEATH RATES FOR ALIQUIPPA BOROUGH, PA.: 1971

Variables	Original	Revised (1) (Based on known changes in both births and deaths)	Revised (11) (Based on maximum possible changes in both births and deaths)
Total deliveries	323	318	304
Live births	305	303	289
Still births	18	15	15
Neonatal deaths	9	5	5
Infant deaths	12	7	7
Fetal death rate1)	55.7	47.2	49.3
Neonatal death rate2)	29.5	16.5	17.3
Infant death rate3)	39.3	23.1	24.2

1) per 1,000 deliveries

2) per 1,000 live births

3) per 1,000 live births

TABLE 4: LIVE BIRTHS AND INFANT DEANTHS IN ALIQUIPPA AND SURROUNDING COMMUNITIES, 1970 and 1971: ORIGINAL AND REVISED DATA

Place	1970 Live Births	1970 Number of Infant Deaths		1971 Number of Live Births		1971 Number of Infant Deaths		1971 Infant Death Rate Per 1,000 Live Births	
		Original	Revised	Original	Revised	Original	Revised	Original	Revised
Aliquippa Borough	387	17	14	305	303	12	7	39.3	23.1
Surrounding Communities:	748	6	9	768	770	7	11	9.1	14.3
Ambridge Borough	161	3	3	167	169	1	1	6.0	5.9
Baden Borough	68	-	-	65	65	1	1	15.4	15.4
Economy Borough	95	2	2	108	108	1	1	9.3	9.3
Harmony Township	40	-	-	40	40	-	-	-	-
Center Township	153	-	-	164	164	1	2	6.1	12.2
Conway Borough	39	-	-	37	37	-	-	-	-
Hopewell Township	178	1	4	173	173	2	5	11.6	28.9
South Heights Borough	14	-	-	14	14	1	1	71.4	71.4
Total:	1,135	23	23	1,073	1,073	19	18*	17.7	16.8*

*Excludes one infant death: mother's place of residence reported as Aliquippa Borough but actually Hanover Township.

Note: 1. State average infant mortality rate for 1971: 18.3 per 1,000 live births.

2. Infant death rates for 1970 are not reported due to lack of revised birth data.

3. 1971 infant death rates are revised for corrected place of mother's residence for both births and deaths reported for Aliquippa. These rates were not revised for possible births or deaths that should have been allocated to Aliquippa but were allocated to some other geographic region.

TABLE 5a: BIRTHS, FETAL DEATHS, NEONATAL DEATHS, INFANT DEATHS, AND DEATHS FROM CERTAIN DISEASES OF EARLY INFANCY: ALIQUIPPA BOROUGH, BEAVER COUNTY, AND PENNSYLVANIA, 1961-1971

Variable and Place	1961-1971	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Total deliveries												
Pennsylvania	2,283,853	244,818	230,791	225,866	222,773	208,027	199,034	192,295	189,268	188,714	196,649	185,018
Beaver County	39,286	4,589	4,216	3,962	3,841	3,501	3,467	3,252	3,035	3,065	3,204	3,154
Aliquippa Borough	4,657	591	517	470	430	422	395	375	381	351	402	323
Live births												
Pennsylvania	2,239,165	240,172	226,393	221,537	218,515	204,105	195,869	188,706	185,729	185,046	192,154	180,939
Beaver County	38,512	4,493	4,127	3,873	3,774	3,431	3,400	3,178	2,986	3,015	3,134	3,101
Aliquippa Borough	4,494	572	498	450	419	404	380	358	376	345	387	305
Fetal deaths												
Pennsylvania	44,688	4,646	4,398	4,329	4,258	3,922	3,765	3,589	3,539	3,668	4,495	4,079
Beaver County	774	96	89	89	67	70	67	74	49	50	70	53
Aliquippa Borough	163	19	19	20	11	18	15	17	5	6	15	18
Neonatal deaths												
Pennsylvania	38,279	4,357	4,135	3,979	3,869	3,592	3,354	3,261	3,154	3,003	3,027	2,548
Beaver County	626	92	70	41	57	43	53	50	51	64	51	54
Aliquippa Borough	114	15	15	9	8	10	9	6	9	11	13	9
Infant deaths												
Pennsylvania	49,507	5,639	5,370	5,178	5,029	4,737	4,323	4,158	4,015	3,865	3,879	3,314
Beaver County	785	114	87	56	71	57	69	62	65	73	69	62
Aliquippa Borough	147	21	19	14	8	12	14	8	10	12	17	12
Certain diseases of early infancy												
Pennsylvania	31,414	3,625	3,466	3,308	3,224	3,002	2,800	2,762	2,481	2,348	2.391	2,007
Beaver County	511	74	63	34	40	37	44	49	39	47	42	42
Aliquippa Borough	99	13	11	9	8	8	7	7	8	9	12	7

TABLE 5b: RATES FOR LIVE BIRTHS, FETAL DEATHS, NEONATAL DEATHS, INFANT DEATHS AND DEATHS DUE TO CERTAIN DISEASES OF EARLY INFANCY: ALIQUIPPA BOROUGH, BEAVER COUNTY, AND PENNSYLVANIA, 1961-1971

Place and Variables	1961-1971	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Live births[1)]												
Pennsylvania	17.9	20.9	19.9	19.4	19.1	17.7	16.8	16.2	15.8	15.7	16.3	15.1
Beaver County	17.6	21.8	20.1	19.7	19.2	17.5	17.0	15.8	14.6	14.8	15.0	14.9
Aliquippa Borough	18.2	22.1	19.5	19.0	18.3	17.7	16.8	15.8	16.5	15.0	17.4	14.0
Fetal deaths[2)]												
Pennsylvania	19.6	19.0	19.1	19.2	19.1	18.9	18.9	18.7	18.7	19.4	22.9	22.0
Beaver County	19.7	20.9	21.1	22.5	17.4	20.0	19.3	22.8	16.1	16.3	21.8	16.8
Aliquippa Borough	35.0	32.1	36.8	42.6	25.6	42.7	38.0	45.3	13.1	17.1	37.3	55.7
Neonatal deaths[3)]												
Pennsylvania	17.1	18.1	18.3	18.0	17.7	17.6	17.1	17.3	17.0	16.2	15.8	14.1
Beaver County	16.3	20.5	17.0	10.6	15.1	12.5	15.6	15.7	17.1	21.2	16.3	17.4
Aliquippa Borough	25.4	26.2	30.1	20.0	19.1	24.8	23.7	16.8	23.8	31.9	33.7	29.5
Infant deaths[3)]												
Pennsylvania	22.1	23.5	23.7	23.4	23.0	23.2	22.1	22.0	21.6	20.9	20.2	18.3
Beaver County	20.4	25.4	21.1	14.5	18.8	16.6	20.3	19.5	21.8	24.2	22.0	20.0
Aliquippa Borough	32.7	36.7	38.2	31.1	19.1	29.7	36.8	22.3	26.6	34.8	43.9	39.3
Certain diseases of early infancy[4)]												
Pennsylvania	24.6	31.6	30.5	29.0	28.1	26.0	24.1	23.5	21.1	19.9	20.3	16.9
Beaver County	22.9	35.9	30.6	17.3	20.3	18.9	22.0	24.3	19.1	23.1	20.5	20.1
Aliquippa Borough	38.7	50.2	43.2	38.0	34.9	35.1	31.0	30.8	34.9	39.1	53.9	32.1

Notes:
1) Rate per 1,000 population
2) Rate per 1,000 deliveries
3) Rate per 1,000 live births
4) Rate per 100,000 population

TABLE 5c: ORIGINAL, REVISED, AND EXPECTED NUMBER OF DELIVERIES, FETAL DEATHS, AND FETAL DEATH RATES: ALIQUIPPA, 1971

Type of Data	Deliveries			Fetal Deaths			Fetal Death Rate Per 1,000 Deliveries		
	Total	White	Nonwhite	Total	White	Nonwhite	Total	White	Nonwhite
Original	323	206	117	18	7[3)]	11	55.7	34.0	94.0
Revised[1)]	317	200	117	14	3	11	44.2	15.0	94.0
Expected[2)]				9.7	3.5	6.2	30.6	17.5	53.0

1) Revised figures based on known changes in both births and deaths due to reclassification of place of residence.

2) Expected number of fetal deaths based on Pennsylvania fetal death rates by race, 1971.

3) Includes one fetal death, race unknown.

Note: Six(thirty-three percent) of the 18 original fetal deaths in Aliquippa were due to termination of pregnancy(therapeutic abortion). Four were nonwhite, one white, and one race unknown. The mother of one of these(race unknown) was not actually a resident of Aliquippa. Five of these six pregnancies were terminated in Allegheny County Hospitals.

TABLE 5d: FETAL DEATHS BY CAUSE AND RACE, ORIGINAL AND REVISED COUNTS: ALIQUIPPA, PENNSYLVANIA, 1971

Cause of Death	ICDA Code	Number of Fetal Deaths			Fetal Death Rate Per 1,000 Deliveries		
		All Races	White	Nonwhite	All Races	White	Nonwhite
				Original			
All causes		18	7	11	55.7	34.0	94.0
Difficult labor with malposition of fetus	766.9	1	1	-	3.1	4.9	-
Multiple pregnancy	769.4	1	1	-	3.1	4.9	-
Conditions of placenta	770.0,770.9	4	2	2	12.4	9.7	17.1
Conditions of umbilical cord	771.1,771.9	3	-	3	9.3	-	25.6
Termination of pregnancy(therapeutic abortion)	773	6	2*	4	18.6	9.7	34.2
Hemolytic disease of newborn without mention of kernicterus(with Rh incompatibility)	775.0	1	-	1	3.1	-	8.5
Immaturity unqualified	777	1	-	1	3.1	-	8.5
Fetal death of unknown cause	779.9	1	1	-	3.1	4.9	-
				Revised			
All causes		14	3	11	43.9	14.9	94.0
Multiple pregnancy	769.4	1	1	-	3.1	5.0	-
Conditions of placenta	770.0,770.9	2	-	2	6.3	-	17.1
Conditions of umbilical cord	771.1,771.9	3	-	3	9.4	-	25.6
Termination of pregnancy(therapeutic abortion)	773	5	1	4	15.7	5.0	34.2
Hemolytic disease of newborn without mention of kernicterus(with Rh incompatibility)	775.0	1	-	1	3.1	-	8.5
Immaturity unqualified	777	1	-	1	3.1	-	8.5
Fetal death of unknown cause	779.9	1	1	-	3.1	5.0	-

* Includes one fetal death, race unknown.

TABLE 5e: FETAL DEATHS BY CAUSE, SEX AND RACE, MOTHER'S PLACE OF RESIDENCE, AND PLACE OF DELIVERY: ALIQUIPPA, PENNSYLVANIA, 1971

Cause of Death	ICDA Code No.	Sex - Race	Place of Residence	Place of Delivery
Difficult labor with malposition of fetus	766.9	White female	Aliquippa*	Aliquippa Hospital, Beaver County
Multiple pregnancy	769.4	White female	Aliquippa	Rochester General Hospital, Beaver County
Conditions of placenta	770.0,770.9	White female	Aliquippa*	Aliquippa Hospital, Beaver County
		Nonwhite female	Aliquippa	Allegheny General Hospital, Allegheny County
		Nonwhite female	Aliquippa	Aliquippa Hospital, Beaver County
		White male	Aliquippa*	Sewickley Valley Hospital, Allegheny County
Conditions of umbilical cord	771.1,771.9	Nonwhite female	Aliquippa	Aliquippa Hospital, Beaver County
		Nonwhite female	Aliquippa	Aliquippa Hospital, Beaver County
		Nonwhite male	Aliquippa	Aliquippa Hospital, Beaver County
Termination of pregnancy	773	Nonwhite male	Aliquippa	Western Penna. Hospital, Allegheny County
		Nonwhite male	Aliquippa	Western Penna. Hospital, Allegheny County
		(Unknown) male	Aliquippa*	Magee Woman's Hospital, Allegheny County
		Nonwhite male	Aliquippa	Magee Women's Hospital, Allegheny County
		White male	Aliquippa	Magee Women's Hospital, Allegheny County
		Nonwhite female	Aliquippa	Aliquippa Hospital, Beaver County
Hemolytic disease of newborn without mention of kernicterus(Rh incompatibility)	775.0	Nonwhite male	Aliquippa	Aliquippa Hospital, Beaver County
Immaturity, unqualified	777	Nonwhite male	Aliquippa	Aliquippa Hospital, Beaver County
Cause unknown	779.9	White female	Aliquippa	Sewickley Valley Hospital, Allegheny County

* Place of residence of mother originally indicated to be Aliquippa, however, subsequent investigation has shown actual place of residence to be Hopewell Township, Beaver County.

TABLE 5f: SELECTED CAUSES OF FETAL DEATHS BY PLACE OF DELIVERY, ORIGINAL AND REVISED COUNTS: ALIQUIPPA, PENNSYLVANIA, 1971

Cause of Death		Number of Fetal Deaths		
		Total	Place of Delivery	
			Beaver County Hospitals	Allegheny County Hospitals
			Original	
All causes		18	10	8
Termination of pregnancy	773.0	6	1	5
Other causes of death	Residual	12	9	3
			Revised	
All causes		14	8	6
Termination of pregnancy	773.0	5	1	4
Other causes of death	Residual	9	7	2

TABLE 6a: SELECTED CHARACTERISTICS OF BIRTHS: 1971

Variables	Aliquippa	Beaver County	Pennsylvania
% Nonwhite births	34.8(1971) 37.5(1970)	8.4(1971) 9.2(1970)	13.4(1971) 13.3(1970)
Birth-order:			
% First-born	42.0(1971) 32.6(1970)	38.9(1971) 36.5(1970)	37.9(1971) 37.0(1970)
% Over 7th	2.6(1971) 1.8(1970)	1.0(1971) 1.7(1970)	1.7(1971) 1.9(1970)
% Illegitimate births	19.0(1971) 19.1(1970)	7.7(1971) 7.9(1970)	9.9(1971) 9.8(1970)
% Premature births	8.2(1971) 12.1(1970)	7.8(1971) 7.8(1970)	7.6(1971) 7.9(1970)

Note: Although maternal exposure to ionizing radiation to a significant extent during pregnancy may cause an increase in the proportion of premature births, a greater proportion of nonwhite births, of first and over 7th births, and of illegitimate births reported in Aliquippa can adequately explain a higher level of infant mortality in the same city.

TABLE 6b: ORIGINAL, REVISED, AND EXPECTED NUMBER OF INFANT DEATHS AND INFANT DEATH RATE: ALIQUIPPA, 1971

Place and Type of Data	Live Births			Infant Deaths			Infant Death Rate Per 1,000 Live Births		
	Total	White	Nonwhite	Total	White	Nonwhite	Total	White	Nonwhite
Pennsylvania:	180,939	156,745	24,194	3,314	2,556	758	18.3	16.3	31.3
Aliquippa:									
Original	305	199	106	12	9	3	39.3	45.2	28.3
Revised1)	303	197	106	7	4	3	23.1	20.3	28.3
Expected2)				6.5	3.2	3.3	21.5	16.3	31.3

1) Includes revised numbers of live births and infant deaths.

2) Based on Pennsylvania infant death rates by race.

TABLE 6c: OBSERVED AND EXPECTED INFANT DEATHS AND INFANT DEATH RATES: PENNSYLVANIA, ALIQUIPPA BOROUGH, AND HARRISBURG CITY, 1964-1966 AVERAGE

Place	All Races, Both Sexes		White		Nonwhite	
	Observed	Expected	Observed	Expected	Observed	Expected
			Infant Deaths			
Pennsylvania	4695.9	4872.4	3688.0	3867.0	1005.4	1007.9
Aliquippa	11.3	11.0	8.0	6.0	3.3	5.0
Harrisburg	43.7	44.3	27.0	22.4	16.7	21.9
			Infant Death Rate			
Pennsylvania	22.8	23.6	20.3	21.3	40,9	41.0
Aliquippa	28.2	27.4	28.7	21.5	27.0	41,0
Harrisburg	29.1	29.5	27.7	23.0	31.7	41.6

Notes: 1) Expected based on United States infant death rates(1964-1966) by race and legitimacy in: Monthly Vital Statistics Report, Vol. 20, No. 9(Supplement), "Infant Mortality Rates by Legitimacy Status: United States, 1964-66," National Center for Health Statistics, U. S. Department of Health, Education, and Welfare.

2) On the basis of a survey of the classification of place of residence reported on infant death certificates for Aliquippa, 1971 and other studies, it is considered likely that white infant deaths for both Aliquippa Borough and Harrisburg City are overstated.

TABLE 7: SELECTED CHARACTERISTICS OF BIRTHS: ALIQUIPPA BOROUGH, BEAVER COUNTY, AND PENNSYLVANIA, 1961-1971

Variable and Place	1961-1971	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
% Nonwhite births												
Pennsylvania	12.1	11.0	11.5	11.4	11.7	12.0	12.0	12.3	12.6	12.8	13.3	13.4
Beaver County	7.8	6.7	7.6	7.2	7.2	7.4	7.5	9.0	8.7	8.7	9.2	8.4
Aliquippa Borough	31.8	23.1	28.5	28.0	28.9	30.2	32.4	36.3	39.4	39.4	37.5	34.8
Birth order:												
% First-born												
Pennsylvania	30.9	25.9	25.7	26.0	26.7	28.9	31.9	32.9	35.0	36.2	37.0	37.8
Beaver County	29.4	24.7	23.0	24.0	24.4	27.9	30.6	32.0	33.7	35.1	36.5	38.9
Aliquippa Borough	31.9	27.6	27.3	27.6	27.7	30.4	33.7	36.9	35.1	37.4	32.6	42.0
% Over Seventh												
Pennsylvania	2.8	3.0	3.3	3.4	3.4	3.4	3.1	2.7	2.4	2.2	1.9	1.7
Beaver County	2.5	2.6	3.2	2.9	3.4	2.4	2.9	2.1	2.5	1.9	1.7	1.0
Aliquippa Borough	4.3	3.7	6.0	3.8	6.4	4.5	6.6	3.6	5.3	2.6	1.8	2.6
% Illegitimate births												
Pennsylvania	7.2	4.7	5.1	5.5	5.9	6.8	7.3	8.1	8.7	9.2	9.8	9.9
Beaver County	5.0	2.6	3.1	3.1	4.1	4.7	4.8	5.9	6.0	7.4	7.9	7.7
Aliquippa Borough	12.3	4.5	9.6	8.9	9.8	11.4	12.1	14.5	14.1	20.0	19.1	19.0
Infant deaths												
Beaver County												
Observed	785	114	87	56	71	57	69	62	65	73	69	62
Expected	819	101	95	87	83	76	72	68	62	60	61	54
Aliquippa Borough												
Observed	147	21	19	14	8	12	14	8	10	12	17	12
Expected	118	15	14	12	11	11	10	10	10	9	9	7

Note: Expected number based on Pennsylvania infant death rates by race in each of the indicated years.

TABLE 8: INFANT DEATHS, NUMBER AND RATE ACCORDING TO DISTANCE FROM SHIPPINGPORT, 1961-1971

Year	Within 5 miles		Between 5 and 10 miles		Beyond 10 miles		Beaver County	Pennsylvania
	Number	Rate	Number	Rate	Number	Rate		
1961	7	19.4	66	25.1	38	25.6	25.4	23.5
1962	6	18.3	44	19.2	34	23.2	21.1	23.7
1963	6	18.5	34	16.1	16	11.4	14.5	23.4
1964	8	24.4	34	16.2	27	20.5	18.8	23.0
1965	5	16.3	34	17.7	18	15.1	16.6	23.2
1966	10	36.1	34	17.9	25	20.4	20.3	22.1
1967	4	15.2	38	21.2	20	17.9	19.5	22.0
1968	5	19.5	37	21.9	22	21.2	21.8	21.6
1969	4	14.8	47	28.7	22	19.8	24.2	20.9
1970	6	17.2	40	22.9	22	20.1	22.0	20.2
1971	12	42.6	25	14.9	25	21.9	20.0	18.3
Average		22.2		20.1		19.8	20.4	22.0

Note: Rates are "crude" or not adjusted for race or any other factors.

TABLE 9: LIVE BIRTHS, INFANT DEATHS AND AVERAGE INFANT MORTALITY RATES FOR 1961-1971 PERIOD IN "ON-RIVER" COMMUNITIES, BEAVER COUNTY, PA.

Communities ("On-River")	Live Births	Infant Deaths	Infant Death Rate* 1961-1971 Average
Glasgow	8	0	0.0
Ohioville	586	8	13.7
Midland	1,086	32	29.5
Industry	505	11	21.8
Borough	653	13	19.9
Brighton	1,120	15	13.4
Bridgewater	233	8	34.3
Rochester	608	11	18.1
Freedom	463	9	19.4
Conway	449	8	17.8
Economy	1,156	20	17.3
Baden	1,009	19	18.8
Harmony	567	1	1.8
Ambridge	2,059	36	17.5
South Heights	148	7	47.3
Hopewell	2,357	32	13.6
Aliquippa	4,494	147	32.7
Center	1,792	10	5.6
Monaca	1,556	36	23.1
Potter	87	0	0.0
Racoon	537	12	22.3
Shippingport	75	3	40.0
Greene	348	7	20.1
Georgetown	44	1	22.7
Total	21,940	446	20.3

* Rate per 1,000 live births.

TABLE 10a: INFANT DEATHS BY CAUSE: PENNSYLVANIA, ALIQUIPPA AND SURROUNDING COMMUNITIES (ORIGINAL AND REVISED PLACE OF RESIDENCE), 1970-1971

Cause of Death	ICDA Code No.	Pennsylvania	Aliquippa Area		Aliquippa Borough		Balance of Area	
			Original	Revised*	Original	Revised*	Original	Revised*
All Causes	000-999	7,192	42	41	29	21	13	20
Infective and Parasitic Diseases	000-136	161	4	4	1	1	3	3
Enteritis due to other specified organism	008	5	1	1	-	-	1	1
Diarrheal disease	009	40	1	1	-	-	1	1
Septicemia	038	67	2	2	1	1	1	1
Other		49	-	-	-	-	-	-
Diseases of the Respiratory System	460-519	444	4	4	3	3	1	1
Acute interstitial pneumonia	484	26	1	1	-	-	1	1
Broncho pneumonia, unspecified	485	106	2	2	2	2	-	-
Pneumonia, unspecified	486	162	1	1	1	1	-	-
Other		150	-	-	-	-	-	-
Congenital Anomalies	740-759	1,238	6	5	5	4	1	1
Anencephalus	740	115	1	1	-	-	1	1
Congenital anomalies of heart	746	454	4	3	4	3	-	-
Congenital anomalies of urinary system	753	42	1	1	1	1	-	-
Other		627	-	-	-	-	-	-
Certain Causes of Perinatal Mortality	760-778	4,397	27	27	19	12	8	15
Other complications of pregnancy and childbirth	769	591	7	7	6	3	1	4
Conditions of placenta	770	233	2	2	1	1	1	1
Anoxic and hypoxic conditions, NEC	776	2,049	13	13	9	6	4	7
Immaturity unqualified	777	755	5	5	3	2	2	3
Other		769	-	-	-	-	-	-
Accidental Deaths	800-949	170	1	1	1	1	-	-
Accidental mechanical suffocation	913	43	1	1	1	1	-	-
Other		127	-	-	-	-	-	-
All Other Causes		782	-	-	-	-	-	-

*Revised rates were corrected for errors in reporting mother's place of residence. These rates were not corrected for the number of live births incorrectly allocated to Aliquippa or surrounding communities nor were they revised for possible births or deaths that should have been allocated to Aliquippa or surrounding communities but were allocated to some other geographic region.

TABLE 10b: INFANT DEATH RATES BY CAUSE: PENNSYLVANIA, ALIQUIPPA AND SURROUNDING COMMUNITIES (ORIGINAL AND REVISED PLACE OF RESIDENCE), 1970-1971

Cause of Death	ICDA Code No.	Pennsylvania	Aliquippa Area		Aliquippa Borough		Balance of Area	
			Original	Revised*	Original	Revised*	Original	Revised*
All Causes	000-999	19.3	19.0	18.6	41.9	30.3	8.6	13.2
Infective and Parasitic Diseases	000-136	0.4	1.8	1.8	1.4	1.4	2.0	2.0
Enteritis due to other specified organism	008	0.0	0.5	0.5	-	-	0.7	0.7
Diarrheal disease	009	0.1	0.5	0.5	-	-	0.7	0.7
Septicemia	038	0.2	0.9	0.9	1.4	1.4	0.7	0.7
Other		0.1	-	-	-	-	-	-
Diseases of the Respiratory System	460-519	1.2	1.8	1.8	4.3	4.3	0.7	0.7
Acute interstitial pneumonia	484	0.1	0.5	0.5	-	-	0.7	0.7
Broncho pneumonia, unspecified	485	0.3	0.9	0.9	2.9	2.9	-	-
Pneumonia, unspecified	486	0.4	0.5	0.5	1.4	1.4	-	-
Other		0.4	-	-	-	-	-	-
Congenital Anomalies	740-759	3.3	2.7	2.3	7.2	5.8	0.7	0.7
Anencephalus	740	0.3	0.5	0.5	-	-	0.7	0.7
Congenital anomalies of heart	746	1.2	1.8	1.4	5.8	4.3	-	-
Congenital anomalies of urinary system	753	0.1	0.5	0.5	1.4	1.4	-	-
Other		1.7	-	-	-	-	-	-
Certain Causes of Perinatal Mortality	760-778	11.8	12.2	12.2	27.5	17.3	5.3	9.9
Other complications of pregnancy and childbirth	769	1.6	3.2	3.2	8.7	4.3	0.7	2.6
Conditions of placenta	770	0.6	0.9	0.9	1.4	1.4	0.7	0.7
Anoxic and hypoxic conditions, NEC	776	5.5	5.9	5.9	13.0	8.7	2.6	4.6
Immaturity unqualified	777	2.0	2.3	2.3	4.3	2.9	1.3	2.0
Other		2.1	-	-	-	-	-	-
Accidental Deaths	800-949	0.5	0.5	0.5	1.4	1.4	-	-
Accidental mechanical suffocation	913	0.1	0.5	0.5	1.4	1.4	-	-
Other		0.3	-	-	-	-	-	-
All Other Causes		2.1	-	-	-	-	-	-

*Revised rates were corrected for errors in reporting mother's place of residence. These rates were not corrected for the number of live births incorrectly allocated to Aliquippa or surrounding communities nor were they revised for possible births or deaths that should have been allocated to Aliquippa or surrounding communities but were allocated to some other geographic region.

TABLE 11: SPECIFIC CAUSES OF DEATH: INFANT DEATHS IN ALIQUIPPA(1970)[1]

1. Cardiac arrest; hyperkalemia(potassium); prematurity; hydronephrosis
2. Prematurity; hyaline membrane disease
3. Cardio-respiratory arrest; idiopathic respiratory distress syndrome
4. Prematurity; premature separation of placenta; hyaline membrane disease
5. Pneumonia
6. Bronchopneumonia
7. Bilateral pneumothorax; idiopathic respiratory distress syndrome; prematurity; hypobilirubinemia
8. Hyaline membrane disease
9. Cardio-respiratory arrest; massive pulmonary hemorrhage; respiratory distress syndrome
10. Bronchopneumonia; cleft palate; horse-shoe kidney; megaloureter
11. Immaturity; prematurity
12. Cardio-respiratory arrest; congenital heart disease; bronchopneumonia
13. Immaturity; anoxia
14. Immaturity; anoxia

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[1] Revised number of deaths reflects changes due to incorrect allocation of place of residence (See Table 4)

TABLE 12: OBSERVED AND EXPECTED INFANT DEATH RATES BY RACE FOR SELECTED COMMUNITIES, PENNSYLVANIA: 1961-1971 AVERAGE

Community	All Races		White		Nonwhite	
	Observed	Expected	Observed	Expected	Observed	Expected
Aliquippa	32.7	26.1	29.4	19.8	39.8	39.3
Clairton	23.4	25.5	17.9	19.8	37.0	39.7
Coatesville	29.4	26.3	18.5	19.7	50.4	39.2
Farrell	27.6	27.6	20.5	20.0	38.5	39.4
Harrisburg	30.3	27.3	25.7	19.9	37.7	39.1
Norristown	27.7	23.4	25.4	19.6	37.8	39.5
Pottstown	32.4	22.5	30.0	19.8	47.7	39.6
West Chester	32.0	25.1	29.8	19.8	37.3	38.9
Wilkinsburg	23.4	23.6	23.2	19.9	24.4	38.3

Notes: 1. Rates per 1,000 live births.

2. Expected rates based on annual race specific infant death rates for Pennsylvania and the annual number of live births in the corresponding race group in the above communities over the period 1961-1971. Variation in the average expected race specific deaths rates among communities largely due to the differing patterns of change in the annual number of live births in these communities which accompanied the general decline in the infant death rate during this period.

3. Observed rates were based on the numbers of infant deaths uncorrected for place of residence; this may tend to overstate the death rate for whites more often than for nonwhites because of the fact that relatively more whites live in the suburban areas along both sides of the city lines where misallocation of place of residence can occur.

PART II. DATA ON NEOPLASMS, ALIQUIPPA, OTHER SELECTED COMMUNITIES, AND PENNSYLVANIA

Table 13	Cancer Death Rates According to Distance from Shippingport, 1961-1971
Table 14	Death Rates per 100,000 Due to Malignant Neoplasms, all Sites and Bone-Connective Tissue-Skin-Breast According to Distance from Shippingport, 1969-1971 Average
Table 15	Death Rates per 100,000 Due to Neoplasms of Lymphatic and Hematopoietic Tissue According to Distance from Shippingport, 1969-1971 Average
Table 16	Population, Deaths and Average Death Rates Due to Malignant Neoplasms, all Sites and Bone-Connective Tissue-Skin-Breast for 1969-71 Period in "On-River" Communities, Beaver County, Pennsylvania
Table 17	Resident Deaths Due to Cancer, Number and Rate: Midland, Pennsylvania, 1961-1971
Table 18	Population, Deaths and Average Death Rates Due to Neoplasms of Lymphatic and Hematopoietic Tissues for 1969-1971 Period in "On-River" Communities, Beaver County, Pennsylvania
Table 19	Resident Deaths Due to Neoplasms of Hematopoietic Tissue, Number and Rate: Midland, Pennsylvania, 1961-1971
Table 20	Number and Rate of Deaths Due to Neoplasms of Lymphatic and Hematopoietic Tissue, and Percentage Distribution of Deaths by Specific Tumor Type; Pennsylvania, Beaver County and Aliquippa: 1969-1971 Average
Table 21	Deaths Due to Neoplasms of Lymphatic and Hematopoietic Tissue (200-209) of Aliquippa Residents in 1969, 1970 and 1971
Table 22	Leukemia Death Rates per 100,000 Population

TABLE 13: CANCER DEATH RATES ACCORDING TO DISTANCE FROM SHIPPINGPORT, 1961-1971

Year	Within 5 miles	Between 5 and 10 miles	Beyond 10 miles	Beaver County	Pennsylvania
1961	115.8	153.6	145.0	147.8	175.4
1962	188.3	162.0	161.9	164.1	175.2
1963	127.1	144.1	131.0	138.4	177.3
1964	102.6	161.6	149.2	152.7	179.1
1965	180.4	173.4	150.1	166.1	179.7
1966	119.9	164.5	163.8	160.7	182.5
1967	143.4	156.5	184.5	164.9	184.1
1968	172.7	201.4	206.5	200.8	188.6
1969	225.6	189.2	164.9	183.9	188.3
1970	218.9	191.2	164.3	184.2	186.6
1971	117.9	177.3	169.4	170.2	188.9
Average 1961-1971	155.7	170.4	162.8	166.7	182.3
Population	16,905	120,308	71,205	208,418	11,793,909

Note: Rates per 100,000 population(all ages).

TABLE 14: DEATH RATES PER 100,000 DUE TO MALIGNANT NEOPLASMS, ALL SITES AND BONE-CONNECTIVE TISSUE-SKIN-BREAST ACCORDING TO DISTANCE FROM SHIPPINGPORT, 1969-1971 AVERAGE

Malignant Neoplasms	Within 5 miles	Between 5 and 10 miles	Beyond 10 miles	Beaver County	Pennsylvania
All Sites	187.3	185.9	166.2	179.4	188.0
Bone-Conn. Tissue-Skin-Breast	21.7	14.7	15.9	15.7	21.7

TABLE 15: DEATH RATES PER 100,000 DUE TO NEOPLASMS OF LYMPHATIC AND HEMATOPOIETIC TISSUE ACCORDING TO DISTANCE FROM SHIPPINGPORT, 1969-1971 AVERAGE

Neoplasms	Within 5 miles	Between 5 and 10 miles	Beyond 10 miles	Beaver County	Pennsylvania
Total (Lymphatic-Hematopoietic)	19.7	20.5	13.1	17.9	17.2
Leukemia/ Aleukemia	7.9	7.8	8.0	7.8	7.5
Other Lymphatic and Hematopoietic	11.8	12.7	5.1	10.1	9.7

Note: Rates are "crude" or not adjusted for race or any other factors, and apply to all ages.

TABLE 16: POPULATION, DEATHS AND AVERAGE DEATH RATES DUE TO MALIGNANT NEOPLASMS, ALL SITES AND BONE-CONNECTIVE TISSUE-SKIN-BREAST FOR 1969-1971 PERIOD IN "ON-RIVER" COMMUNITIES, BEAVER COUNTY, PENNSYLVANIA

Communities ("On-River")	Population 1970	All Sites		Bone-Connective Tissue-Skin-Breast	
		Number of Deaths	Average Death Rate	Number of Deaths	Average Death Rate
Glasgow(30-31 yr.)	112	1	297.6	0	0.0
Ohioville(under 26 yr)	3,918	11	93.6	3	25.5
Midland(32-33 yr)	5,271	50	316.2	4	25.3
Industry(28-29 yr.)	2,442	14	191.1	0	0.0
Borough(28-29 yr.)	2,122	9	141.4	0	0.0
Brighton(30-31 yr.)	7,532	33	146.0	5	22.1
Bridgewater(32-33 yr.)	966	12	414.1	1	34.5
Rochester(28-29 yr.)	4,819	34	235.2	3	20.8
Freedom(30-31 yr.)	2,643	22	277.5	1	12.6
Conway(28-29 yr.)	2,822	14	165.4	0	0.0
Economy(28-29 yr.)	7,176	29	134.7	2	9.3
Baden(34-35 yr.)	5,536	29	174.6	2	12.0
Harmony(36-37 yr.)	5,022	21	139.4	0	0.0
Ambridge(38+ yr.)	11,324	115	338.5	11	32.4
South Heights(30-31 yr.)	799	1	41.7	0	0.0
Hopewell(30-31 yr.)	14,133	53	125.0	6	14.2
Aliquippa(32-33 yr.)	22,277	141	211.0	10	15.0
Center(under 26 yr.)	10,598	32	100.6	1	3.1
Monaca(32-33 yr.)	7,486	65	289.4	5	22.3
Potter(30-31 yr.)	484	0	0.0	0	0.0
Racoon(under 26 yr.)	2,615	9	114.7	2	25.5
Shippingport(26-27 yr.)	328	2	203.3	1	101.6
Greene(under 26 yr.)	1,489	8	179.1	1	22.4
Georgetown(30-31 yr.)	234	2	284.9	0	0.0
Total	122,148	707	192.9	58	15.8

Notes: (a) Figures in parentheses under Communities indicate median age of population.
(b) Rates per 100,000 population.

TABLE 17: RESIDENT DEATHS DUE TO CANCER, NUMBER AND RATE: MIDLAND, PENNSYLVANIA, 1961-1971

Year	Cancer, All Sites	
	Number	Rate
1961	6	95.1
1962	9	145.3
1963	11	181.0
1964	7	117.4
1965	18	307.8
1966	5	87.2
1967	10	178.0
1968	10	181.8
1969	20	371.3
1970	22	417.4
1971	8	155.2
1961-1971	126	199.8

Note: Rates per 100,000 population. Rates for intercensal years based on populations estimated by linear interpolation.

TABLE 18: POPULATION, DEATHS AND AVERAGE DEATH RATES DUE TO NEOPLASMS OF LYMPHATIC AND HEMATOPOIETIC TISSUES FOR 1969-1971 PERIOD IN "ON-RIVER" COMMUNITIES, BEAVER COUNTY, PA.

Communities ("On-River")	Population 1970	Leukemia and Aleukemia		Other Lymphatic and Hematopoietic	
		Number of Deaths	Average Death Rate	Number of Deaths	Average Death Rate
Glasgow	112	0	0.0	0	0.0
Ohioville	3,918	0	0.0	0	0.0
Midland	5,271	3	19.0	2	12.6
Industry	2,442	0	0.0	2	27.3
Borough	2,122	0	0.0	1	15.7
Brighton	7,532	2	8.9	4	17.7
Bridgewater	966	0	0.0	1	34.5
Rochester	4,819	2	13.8	2	13.8
Freedom	2,643	2	25.2	2	25.2
Conway	2,822	1	11.8	0	0.0
Economy	7,176	0	0.0	1	4.6
Baden	5,536	1	6.0	2	12.0
Harmony	5,022	0	0.0	2	13.3
Ambridge	11,324	5	14.7	4	11.8
South Heights	799	0	0.0	0	0.0
Hopewell	14,133	2	4.7	3	7.1
Aliquippa	22,277	8	12.0	13	19.5
Center	10,598	2	6.3	3	9.4
Monaca	7,486	2	8.9	1	4.5
Potter	484	0	0.0	0	0.0
Racoon	2,615	0	0.0	1	12.7
Shippingport	328	0	0.0	0	0.0
Greene	1,489	1	22.4	1	22.4
Georgetown	234	0	0.0	1	142.4
Total	122,148	31	8.5	46	12.6

Note: Rate per 100,000 population.

TABLE 19: RESIDENT DEATHS DUE TO NEOPLASMS OF HEMATOPOIETIC TISSUE, NUMBER AND RATE MIDLAND, PENNSYLVANIA, 1961-1971

Year	Neoplasms of Lymphatic and Hematopoietic Tissue		Leukemia and Aleukemia		Other Neoplasms of Lymphatic and Hematopoietic Tissue	
	Number	Rate	Number	Rate	Number	Rate
1961	1	15.8	-	-	1	15.8
1962	-	-	-	-	-	-
1963	-	-	-	-	-	
1964	1	16.8	1	16.8	-	-
1965	-	-	-	-	-	-
1966	-	-	-	-	-	-
1967	2	35.6	1	17.8	1	17.8
1968	-	-	-	-	-	-
1969	1	18.6	1	18.6	-	-
1970	3	56.9	2	37.9	1	19.0
1971	1	19.4	-	-	1	19.4
1961-1971	9	14.3	5	7.9	4	6.3

Note: Rates per 100,000 population. Rates for intercensal years based on populations estimated by linear interpolation.

TABLE 20: NUMBER AND RATE OF DEATHS DUE TO NEOPLASMS OF LYMPHATIC AND HEMATOPOIETIC TISSUE, AND PERCENTAGE DISTRIBUTION OF DEATHS BY SPECIFIC TUMOR TYPE; PENNSYLVANIA, BEAVER COUNTY AND ALIQUIPPA: 1969-1971 AVERAGE

Cause of Death	Number of Deaths			Rate per 100,000 pop.			Percentage Distribution		
	Pa.	Beaver County	Aliquippa	Pa.	Beaver County	Aliquippa	Pa.	Beaver County	Aliquippa
Leukemia and Aleukemia:	2,646	49	8	7.5	7.8	12.0	100.0	100.0	100.0
Lymphatic	896	21	5	2.5	3.4	7.5	33.9	42.9	62.5
Myeloid	1,012	18	3	2.9	2.9	4.5	38.3	36.7	37.5
Monocytic	99	1	0	0.3	0.2	-	3.7	2.0	-
Others	639	9	0	1.8	1.4	-	24.1	18.4	-
Other Neoplasms of Lymphatic and Hematopoietic:	3,442	63	13	9.7	10.1	19.4	100.0	100.0	100.0
Lymphosarcoma	1,234	18	5	3.5	2.9	7.5	35.9	28.6	38.5
Hodgkin's Disease	707	19	2	2.0	3.0	3.0	20.5	30.1	15.4
Others	449	7	3	1.3	1.1	4.5	13.1	11.1	23.1
Multiple Myeloma	818	14	0	2.3	2.2	-	23.7	22.2	-
Polycythemia Vera	90	2	0	0.3	0.3	-	2.6	3.2	-
Myelofibrosis	144	3	3	0.4	0.5	4.5	4.2	4.8	23.0

Note: Rate per 100,000 population(all ages).

TABLE 21: DEATHS DUE TO NEOPLASMS OF LYMPHATIC AND HEMATOPOIETIC TISSUE (200-209) OF ALIQUIPPA RESIDENTS IN 1969, 1970 AND 1971

Death Certificate Number	Sex/ Race	Lived Within City Limits	Date of Death	Age (Years)	ICDA Code	Description
				1969		
022960	WM	Yes	3/20/69	59	201X	Respiratory failure, Hodgkins disease
024017	WM	Yes	3/6/69	54	2001	Lymphosarcoma-3 yrs.
034910	WF	Yes	4/27/69	87	2041	Chronic lymphatic leukemia-2 yrs.
055797	WM	Yes	6/20/69	72	2022	Generalized malignant lymphoma-3 mo.
094256	WM	Yes	10/12/69	76	209X	Bronchopneumonia, Myelofibrosis, G.I. hemorrhage
106039	WF	Yes	11/14/69	76	2001	Lymphosarcoma, generalized-6 mo.
106046	WM	Yes	11/5/69	73	2000	General Metastasis, Reticulum cell sarcoma-20 mo
				1970		
001827	WM	Yes	1/8/70	65	209X	Myocardial failure-3 days., Anemia-2 mo., Myelofibrosis-3 mo., Hypertension
024394	NWM	Yes	3/29/70	79	2030	Acute myelogenous leukemia-3 mo
024412	WF	Yes	3/11/70	79	2050	Acute myelogenous leukemia-7 mo.
065728	WM	Yes	7/3/70	62	2000	Lymphosarcoma(Reticulum cell)-[illegible] yrs
075010	WF	Yes	8/12/70	4	2040	Central Nervous System Leukemia-2 days Acute Lymphocytic leukemia-1½ yrs
116838	WF	Yes	12/1/70	78	2050	Acute myelogenous Leukemia
				1971		
000732	WF	Yes	1/17/71	37	2000	Reticulum Cell Sar[illegible]
23547	WM	Yes	3/31/70	81	209X	Agnogenic myeloid metapla[illegible], [illegible] emphysema, Coronary heart disease
34538	WM	Yes	4/24/70	67	2022	Lymphoma - 2½ years
55877	NWF	Yes	6/15/71	71	2040	Chronic lymphatic leuke[illegible]

TABLE 21: DEATHS DUE TO NEOPLASMS OF LYMPHATIC AND HEMATOPOIETIC TISSUE (200-209) OF ALIQUIPPA RESIDENTS IN 1969, 1970 AND 1971 (CONTINUED)

Death Certificate Number	Sex/ Race	Lived Within City Limits	Date of Death	Age (Years)	ICDA Code	Description
			1971 (Continued)			
064983	WM	Yes	7/17/71	81	2040	Lymphatic leukemia, acute exacerbation-1 yr. Pneumonia, Gram negative sepsis
76103	WM	Yes	8/28/71	76	2041	Chronic lymphatic leukemia-2 yrs. ASHD with congestive failure-4 yrs. Obstructive emphysema
094593	WF	Yes	10/10/71	31	201X	Hodgkins disease-3 yrs.
095520	WM	Yes	10/18/71	33	2022	Lymphoma-2 yrs.

TABLE 22: LEUKEMIA DEATH RATES PER 100,000 POPULATION

Locality	1970 Population	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Aliquippa	22,277	-	19.6	15.9	8.1	16.4	4.2	8.5	17.3	4.4	18.0	13.7
Pottstown	25,355	3.8	15.4	11.6	7.7	3.9	15.6	23.4	11.8	19.7	11.8	11.9
Wilkinsburg	26,780	10.1	13.6	10.3	7.0	3.5	10.7	7.2	10.9	7.4	14.9	11.3
West Chester	19,301	-	6.1	6.0	17.5	17.1	-	5.5	5.4	-	10.4	10.2
Clairton	15,051	11.1	5.6	5.8	-	-	-	12.5	12.7	6.5	-	-
Coatesville	12,331	7.7	-	15.7	7.9	-	15.9	-	8.0	-	16.2	8.2
Farrell	11,022	7.4	7.6	15.4	31.5	8.1	-	8.4	25.9	-	9.1	-
Norristown	38,169	2.6	5.2	10.3	7.8	-	18.2	10.4	7.8	10.5	5.2	5.3
Harrisburg	68,061	8.9	9.0	1.3	14.7	4.1	11.0	9.8	11.4	11.6	10.3	9.0

PART III. DATA ON CAUSE-SPECIFIC MORTALITY, ALIQUIPPA, BEAVER COUNTY, EIGHT SELECTED COMMUNITIES, AND PENNSYLVANIA: 1971

Table 23 Cause-Specific Mortality Rate per 100,000 Population: 1971

Table 24 Cause-Specific Mortality Rates per 100,000 Population: Selected Pennsylvania Municipalities, 1971

TABLE 23: CAUSE-SPECIFIC MORTALITY RATE PER 100,000 POPULATION: 1971

Mortality Rate by Cause	Aliquippa	Beaver County	Pennsylvania
Accidents(motor vehicle)	32.1(7)	15.8	20.4
Asthma	4.6(1)	1.4	1.1
Cerebrovascular disease	142.2(31)	110.2	105.0
Cholelithiasis/cholecystitis	13.8(3)	4.3	1.6
Cirrhosis of liver	41.3(9)	12.9	15.9
Diabetes mellitus	41.3(9)	25.4	22.9
Heart disease	490.8(107)	398.9	448.0
Homicide	13.8(3)	1.9	6.3
Prostatic hypertrophy	4.6(1)	2.9	0.7
Meningitis	4.6(1)	0.5	0.7
Cancer of digestive system	73.4(16)	54.6	55.6
Leukemia	13.8(3)	6.2	7.2
Other lymphatic-hematopoietic cancer	22.9(5)	12.5	10.1
Nephritis/nephrosis	13.8(3)	5.7	4.5
Pneumonia-influenza	27.5(6)	31.6	26.9
Cancer of respiratory system	32.1(7)	33.5	38.2
Cancer of bone, tissue, skin	9.2(2)	13.4	21.7

Note: Figures in parentheses for Aliquippa represent actual numbers of death by specific causes.

TABLE 24: CAUSE SPECIFIC MORTALITY RATES PER 100,000 POPULATION: SELECTED PENNSYLVANIA MUNICIPALITIES, 1971

Mortality Rate by Cause	Aliquippa	Clairton	Coatesville	Farrell	Harrisburg	Norristown	Pottstown	West Chester	Wilkinsburg
Accidents(motor vehicle)	32.1(7)	13.6(2)	57.1(7)	9.3(1)	16.5(11)	15.7(6)	15.8(4)	20.3(4)	30.3(8)
Asthma	4.6(1)	- (-)	- (-)	9.3(1)	1.5(1)	2.6(1)	- (-)	5.1(1)	3.8(1)
Cerebrovascular diseases	142.2(31)	142.7(21)	195.6(24)	121.0(13)	149.7(100)	126.0(48)	114.7(29)	162.8(32)	94.7(25)
Cholelithiasis/cholecystitis	13.8(3)	- (-)	- (-)	9.3(1)	4.5(3)	2.6(1)	- (-)	- (-)	- (-)
Cirrhosis of liver	41.3(9)	13.6(2)	16.3(2)	27.9(3)	25.4(17)	26.2(10)	15.8(4)	20.3(4)	18.9(5)
Diabetes mellitus	41.3(9)	20.4(3)	57.1(7)	46.5(5)	31.4(21)	34.1(13)	59.3(15)	10.2(2)	7.6(2)
Heart diseases	490.8(107)	563.9(83)	529.9(65)	446.7(48)	609.3(407)	582.7(222)	546.0(138)	427.3(84)	697.0(184)
Homicide	13.8(3)	20.4(3)	8.2(1)	37.2(4)	16.5(11)	2.6(1)	11.9(3)	15.3(3)	3.8(1)
Prostatic hypertrophy	4.6(1)	13.6(2)	8.2(1)	- (-)	7.5(5)	2.6(1)	7.9(2)	15.3(3)	3.8(1)
Meningitis	4.6(1)	- (-)	- (-)	- (-)	1.5(1)	- (-)	- (-)	- (-)	3.8(1)
Cancer of digestive system	73.4(16)	129.1(19)	57.1(7)	121.0(13)	71.9(48)	60.4(23)	79.1(20)	30.5(6)	60.6(16)
Leukemia	13.8(3)	- (-)	8.2(1)	- (-)	9.0(6)	5.2(2)	11.9(3)	10.1(2)	11.4(3)
Other lymphatic-hematopoietic cancer	22.9(5)	- (-)	8.2(1)	27.9(3)	16.5(11)	5.2(2)	15.8(4)	5.1(1)	11.4(3)
Nephritis/nephrosis	13.8(3)	20.4(3)	16.3(2)	- (-)	9.0(6)	5.2(2)	4.0(1)	5.1(1)	7.6(2)
Pneumonia-influenza	27.5(6)	13.6(2)	48.9(6)	46.5(5)	41.9(28)	44.6(17)	27.7(7)	- (-)	34.1(9)
Cancer of respiratory system	32.1(7)	34.0(5)	89.7(11)	46.5(5)	55.4(37)	39.4(15)	43.5(11)	35.6(7)	68.2(18)
Cancer of bone, tissue, skin	9.2(2)	27.2(4)	32.6(4)	18.6(2)	31.4(21)	28.9(11)	23.7(6)	40.7(8)	41.7(11)
Population, 1971 estimate	21,800	14,718	12,267	10,745	66,800	38,100	25,277	19,660	26,400

Note: Figures in parentheses represent actual number of deaths by specific causes.

APPENDIX B

A Non-Technical Description of

The Operating Characteristics of a Pressurized Water Reactor

A nuclear power station, like a conventional fossil-fueled station, generates electricity by using steam-driven turbines to turn electric generators. The primary difference between conventional power plants and a nuclear power plant is the source of heat used to convert water into the steam required to drive the turbines. While fossil-fueled plants produce heat by burning large quantities of coal, oil or gas, nuclear power plants produce heat by controlled nuclear fission.

A pressurized water reactor, like the one at Shippingport, is made of a fuel core, control rods, the primary water coolant and a radiation shield called a containment unit (See Figure 1).

The core is a group of fuel elements. The separate fuel elements contain slightly radioactive uranium dioxide encased in metal cladding (See Figure 2). An individual fuel element does not contain enough uranium to produce and sustain nuclear fission. However, when a number of fuel elements are assembled together in the proper environment, their combined concentration of uranium causes nuclear fission to occur. The fission process is a chain-reaction, where uranium atoms in the fuel give off particles called neutrons and these neutrons strike other atoms which release more neutrons to strike yet other atoms. As a result of nuclear fission, heat and radioactive fission products are produced.

The primary water coolant is pumped through the core and as it passes over the fuel elements it absorbs the heat produced by the fission process. In a pressurized water reactor the primary water coolant is maintained under high pressure so that the water does not boil or produce steam and the coolant becomes a super-heated liquid.

The primary water coolant is then pumped from the reactor core to a "Steam Generator," where it is circulated through a series of tubes. A second stream of water is circulated around the tubes containing the super-heated water. The heat absorbed through tubing, causes the second stream of water to boil and produce the steam used to drive the turbines.

It must be emphasized that the primary coolant and the secondary stream of water do not come into direct contact. Heat contained in the former is transferred to the latter through the tubes in the steam generator. Since the two streams of water do not come into direct contact, radioactivity in the primary coolant cannot contaminate the second stream. Also, the primary coolant is a closed system that recirculates from the reactor to the steam generator and back again to the reactor core.

Control rods are made of a material that readily absorbs neutrons. If some of the control rods are removed from the reactor core, more neutrons become available to cause fission and the rate of fission increases. Conversely, if more rods are inserted into the reactor core, fewer neutrons are available to cause fission and the rate of fission decreases. The control rods make it possible to control both the rate of fission and the amount of heat produced. Also, the control rods can be used to completely shut down the reactor.

A pressurized water reactor contains a large amount of radioactive material, both in the fuel elements and to a lesser extent in the primary coolant. A leak in the system could result in the release of considerable amounts of radioactive material. A containment unit is constructed around the primary system to provide a shield from radiation and to contain both the pressurized steam and the heat that would be produced if the water in the primary system were expelled into the containment unit.

Primary Sources of Radioactivity Within a Nuclear Power Plant

Other than the uranium dioxide fuel, radioactive materials in a nuclear power plant arise from two processes: (1) Fission, which occurs in the fuel when the reactor is in operation and (2) Neutron activation which occurs when neutrons, given off by atomic fission, strike nonradioactive atoms in the region of the reactor core and cause these atoms to become radioactive. Fission is by far the predominate source of radioactivity while neutron activation products occur primarily in the metal cladding in which the fuel is encased, in the primary water coolant and, in trace elements contained in the primary water coolant.

During reactor operations, some of the fission products diffuse out of the fuel and into the space between the fuel and the fuel cladding (See Figure 2). Through small defects in the cladding (which can arise from a number of causes) some fission products can escape into the primary water coolant.

During routine reactor operation, radioactive gases (noble gases and neutron activation gases) are removed from the primary coolant. Since the total amount of radioactivity in gaseous waste from recently produced fission products (or in most cases from a mixture of neutron capture products) decreases very sharply over a relatively short period of time, these gases are held in storage tanks. After an appropriate period of time has elapsed to allow for maximum decay of radioactivity, the gases are passed through filter systems and released via the plant release stack to the atmosphere. All releases are conducted under strict specifications established by governmental regulatory agencies.

The non-gaseous radioactive material in the primary water coolant either remains as finely suspended solids or become dissolved in the coolant. The liquid wastes are processed through a waste treatment system where much of the radioactive material is removed. Like gaseous wastes, liquids are stored until the level of the radioactivity has been reduced to a relatively low level. The residual material is then diluted with large quantities of water before it is released into the river.

The treatment of liquid wastes, however, does not remove radioactive tritium from the water. Radioactive tritium is formed in the primary water coolant by neutron activation on water, material dissolved in the water and leakage from fuel elements. There is no known feasible method for removing tritium from water.

The amount of radioactive wastes released during the operation of a nuclear power plant depends on the size and level of operation of the plant and the amount of leakage through the cladding. Furthermore, when a reactor is shut down all the gaseous wastes contained in the primary coolant are removed and held for later release.

It is important to note that under routine operations, only very small quantities of radioactive wastes are released to the environment. Much of the radioactive wastes are packed in barrels and boxes transported by truck from the plant site to storage areas and/or disposal sites.

What Happens to Radioactive Wastes When They are Released into the Environment

The relationships of radioactive wastes and the environment is an extremely complex subject and additional research is needed before we can fully understand the complex systems involved.

When small quantities of gaseous radioactive wastes are released from a nuclear power plant, they are dispersed into the atmosphere. How the gaseous material is initially distributed over the surrounding environment depends on the atmospheric conditions in the area at the time of release.

Environmental processes can cause minute deposits of radioactive materials to be redistributed. Erosion, for example, can cause radioactive deposits in the soil to runoff into streams or valleys. As a result of accumulated runoffs, radioactive wastes can become more concentrated in certain areas. Plants absorb radioactive wastes through leaves, stems, branches, and roots. Under certain types of environmental conditions, plant life and animal life can accumulate and concentrate radioactive wastes that are airborne, deposited in the soil or in the foods they eat.

Liquid wastes discharged into rivers can also be concentrated within the environment. Some of the radioactive wastes released into rivers may accumulate in bottom sediment while some may be concentrated in aquatic plants and animals. Irrigation and floods are yet additional factors that can cause liquid wastes to be redistributed within the environment.

TABLE 1

Summary of estimates of Annual Whole-Body Dose Rates in the United States (1970)

Source	Average Dose Rate* (mrem/yr)	Dose Rate at Reactor Boundary (mrem/yr)
Environmental		
Natural	102	
Global Fallout	4	
Nuclear Power		5
Subtotal	106	
Medical		
Diagnostic	72**	
Radiopharmaceuticals	1	
Subtotal	73	
Occupational	0.8	
Miscellaneous	2	
TOTAL	182	

*Note: The numbers shown are average values only. For given segments of the population, dose rates considerably greater than these may be experienced.

**Based on the abdominal dose.

PRESSURIZED WATER REACTOR

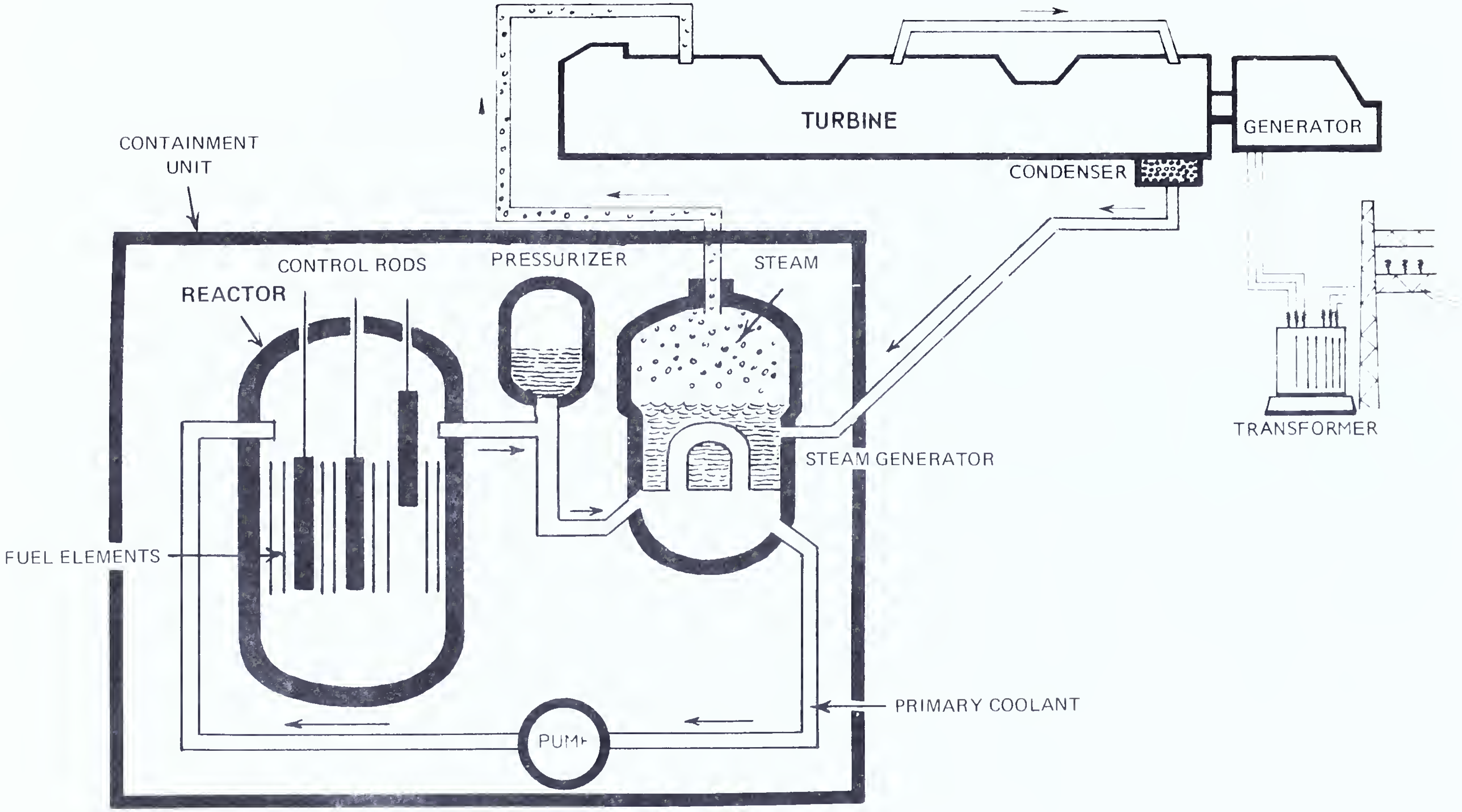

FIGURE 1

CUTAWAY OF OXIDE FUEL FOR COMMERCIAL POWER PLANT

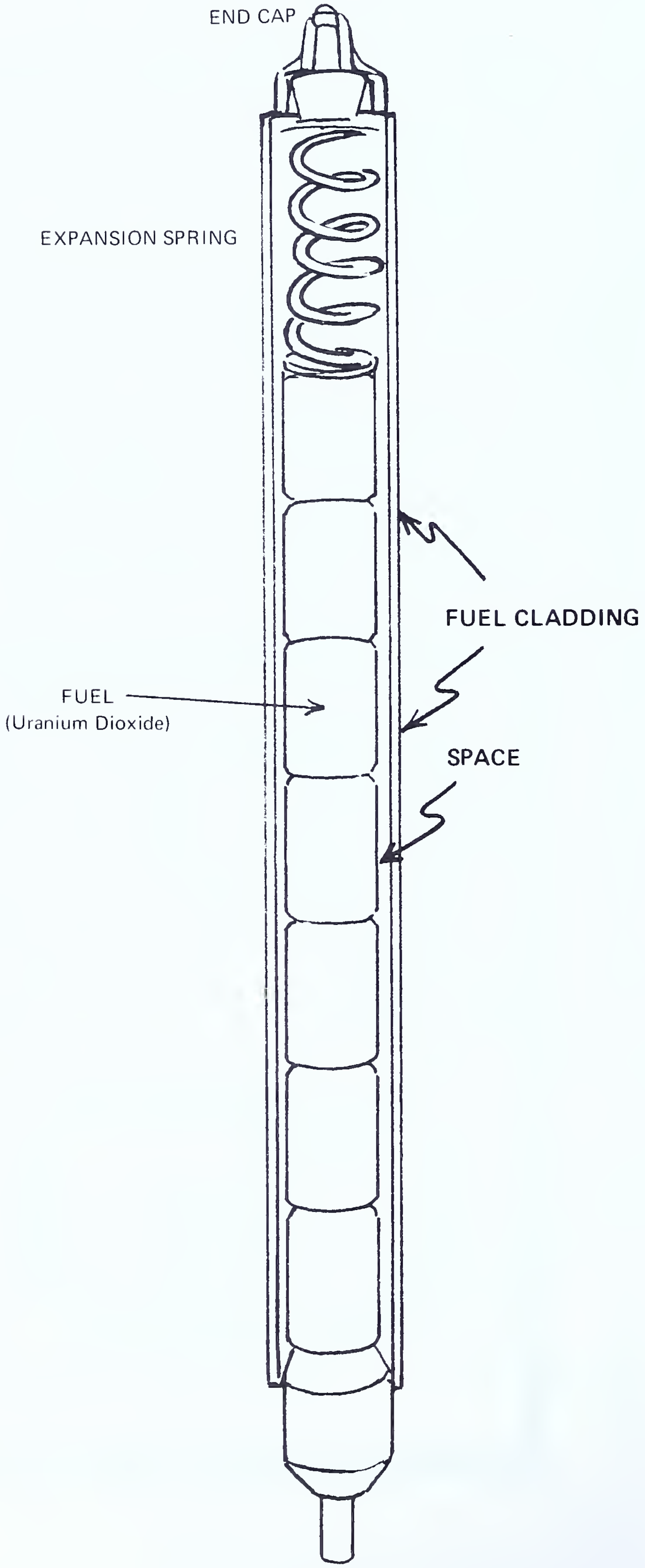

FIGURE 2

SUPPLEMENT TO REPORT OF FACT-FINDING COMMITTEE APPOINTED BY GOVERNOR SHAPP TO INVESTIGATE ALLEGATIONS CONCERNING THE SHIPPINGPORT REACTOR

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Although the testimony at Aliquippa on July 30-31, 1973 ranged over many aspects of nuclear power development, the central issues were the allegations by Dr. Ernest Sternglass that at the Shippingport nuclear plant significant unrecorded releases of airborne radioactive particulates took place on at least two occasions in the past ten years, and as a result of these releases measureable effects on health of the human population living around Shippingport could be detected by examination of available public health records. These allegations raised important subsidiary questions, such as: a) Has the monitoring of radioactivity released from the Shippingport plant been such that the Governor and the public at large can be confident that the releases are clearly defined? b) In quantitative terms, what radiation doses to the population around the plant can be ascribed to plant operations as distinct from fallout from Chinese nuclear bomb tests or other sources? c) What is the validity of Dr. Sternglass' methods used to show associations between alleged exposure to radiation and health effects, such as infant mortality or cancer rates at Shippingport and elsewhere? d) Are the health data on which Dr. Sternglass makes these associations adequate to permit comparisons of the type he has made?

The report of the full Committee speaks to these questions, and in some cases Dr. Sternglass' allegations are dealt with in considerable detail. Notwithstanding this fact, I wish to have included in the record the following additional comments concerning principally Dr. Sternglass' testimony at Aliquippa. In what follows I shall restrict myself to relatively few of the points raised by Dr. Sternglass. Clearly the validity or lack of validity of his assertions on these points will reflect on the validity or lack of validity on other points, especially those clearly related methodologically or conceptually.

Before discussing Dr. Sternglass' testimony however, I should like to offer a few general impressions that came out in the course of the hearings. First, there is a widespread uneasiness about hazards from nuclear reactors in the general public. The facts that radiation is not detectible by our senses, that the devastation wrought by the atomic bombs in Japan is well known, and that accidental releases of radioactivity have occurred from experimental reactors, all contribute to this uneasiness. Second, there is general agreement from the testimony of lay individuals and of the representatives of groups of concerned citizens, that the decision-making machinery for determining the type, size, and location of power plants in Pennsylvania is no longer adequate. Some regulatory mechanisms assuring that citizens can be heard well before a power plant is even designed are necessary to assure that the public will accept a collective decision on these matters.

Third, a substantial responsibility must be assumed by the state in providing adequate pollution monitorning and health data, in order to provide more credibility for the citizens. At present, anyway, the federal agencies and private companies do not have the confidence of the people in these areas, regardless of whether the lack of confidence is justified. Full disclosure of all results to the public will be mandatory to prevent loss of trust in the state agencies. It is not my contention that agencies such as the Atomic Energy Commission or the Environmental Protection Agency have been secretive in any way; it is a fact, however, that many people in Pennsylvania think so, and this is a problem that must be faced squarely.

Monitoring of radioactivity from the Shippingport plant

Mush of the testimony centered around Dr. Sternglass' contention that strontium-90, strontium-89, cesium-137 and other particulate reaionuclides were released from the Shippingport plant into the air on at least two occasions around 1964, when the plant underwent extensive overhauling, and around 1970. These airborne particles then fell out, according to Dr. Sternglass, onto the soil and vegatation, were washed into the rivers, taken up into the dairy cattle and milk, and perhaps directly ingested or inhaled by people living nearby. The amounts of radioactivity thus released were not reported by the operators of the plant, and it is Dr. Sternglass' contention that their routine monitoring program failed to measure these airborne releases. Only the rather accidental discovery from the preliminary site evaluation of the Beaver Valley plants by the NUS Company's measurements brought to light the unreported releases in 1970, according to Dr. Sternglass.

Putting aside any quantitative assessment of the radiation dose to the people that might have occurred even if Dr. Sternglass' assertions were accepted, we have the question whether the monitoring program itself was adequate to determine whether such releases did reach the environment outside the plant. I conclude that it probably was not. Mr. DiNunno of NUS Company stated that with the low releases from normal operation of a plant like Shippingport, a great deal of the monitoring done is an unnecessary waste of time and money. I agree with the statement but at the same time I believe that better surveillance of the environment would be possible. To reassure the public, measurements capable of detecting a significant rise in longer-lived radionuclides outside the plant boundaries are necessary, as well as a continuous check on the effluent pathways (water, stack gases, etc.), with measurements of particularly important radionuclides such as Co-60, I-131, Sr-90 and -89 and the alpha-emitters. Much of the off-site environmental monitoring should be the responsibility of an independent group, sich as a state agency, not the utility or the AEC.

In short, the situation today with respect to public confidence in highly technical environmental pollution measurements is very different than it was when the Shippingport plant began operation. The utilities and state and federal agencies should carefully evaluate just what needs to be measured in order to define the radiation exposures to the public from all kinds of releases from these plants. Some of the current monitoring practices may well be unnecessary, while others may have to be developed and continued for the lifetime of the plant. I think it is especially important to be able to assure the public that no alphaemitting radionuclides are being released to the air or water from the plant. It should be possible to devise methods that would provide this reassurance without requiring a burdensome number of analyses. I am also not sure whether there may be regular releases from the secondary coolant loop at Shippingport. It should be easily possible to provide assurance on this point.

Radiation doses to the population around Shippingport

Dr. Sternglass generally avoided making calculations of radiation doses to the people in Aliquippa or other affected communities, such as Midland or Cincinnati, from the releases he postulated occurred. Dr. Rosenthal, a biologist, also did not make such calculations. In Dr. Sternglass' case, he argued that in some instances, doses could not be calculated because the amount of exposure was not known (i.e. plutonium inhalation by the Japanese after the atomic bombing in relation to the dose to the bronchial epithelium) or because the kinetics of uptake are not known (i.e. fetal concentration of Sr-90 or other isotopes in selected tissues). There may well be disagreement on the kinetic models on which tissue doses may be calculated, but if Dr. Sternglass wishes to challenge those presented by the ICRP or by Dr. Morgan in his textbook, he should do so in a quantitative fashion, that is, give the public an indication of whether the doses are in error by a factor of 2, 10, 100 or some such, and furthermore document why he believes this to be the case. As a highly qualified physicist, Dr. Sternglass is ideally suited to do this, and his avoidance of this responsibility is in my opinion a significant breach in his scientific integrity. The Governor and the public should clearly recognize that failure to provide this important link in the chain of evidence connecting an environmental agency (radiation in this case) to health effects in main is against all scientific principles. If, for example, one wished to make a case that eating rhubarb caused brain cancer, say, then it would be important to know who actually ate rhubarb, how much was eaten, and how much of the products of rhubarb reached the brain, before one could establish that a particular brain cancer had with high probability rhubarb as a contributory factor.

With regard to Dr. Sternglass' assertions that doses cannot be calculated because exposures are not known, the burden of proof rests at least partly on him. To claim that radiation exposure is causing significant increases in infant mortality, cancer, and heart diseases without giving at least a rough indication of the radiation doses that might account for these effects is irresponsible. These are serious assertions, we know that radiation is potentially damaging, and thus every effort should be made to document as quantitatively as possible any instances where a radiation effect may be observed. This is in the tradition of investigators such as Dr. Alice Stewart. If I interpret Dr. Sternglass correctly, relatively low radiation doses may account for the effects he postulates. If he believes this to be the case, it is even more imperative that the quantitative aspects be pursued vigorously for the benefit of the public, since documentation of the dose-response relationship would have important implications for the use of medical x-rays, for example. Moreover, Dr. Sternglass himself is in the best position to make some dose estimates because he knows the data concerning the populations he had studied. The Governor and the people have a right to demand this of him.

Dr. Sternglass drew considerable significance from the fact that milk samples from Pittsburgh showed consistently about 20% more strontiun-90 than milk from Philadelphia or other nearby areas, the implication being that this difference arose from the releases of Sr-90 at Shippingport, Bettis and Waltz Mills. On the assumption that all the increase was due to Shippingport and that one-third of the milk from Pittsburgh came from the milkshed around Shippingport, then in the steady state the Sr-90 content of milk from that milkshed should be about 60% higher than for the rest of the Pittsburgh area. There may not be a steady state, of course, and thus the difference should vary, but as Mr. Michelson showed, only for the 1970-71 period was there evidence that the Pittsburgh milk went above the 20% excess. It seems to me that this evidence that milk is a significant route of entry of Shippingport waste products into the human population is easy to resolve, either by the state or by one of the citizen's groups supporting Dr. Sternglass' position.

It is worth mentioning that Dr. Rosenthal pointed out that variations of Sr-90 concentration of even greater magnitude in milk or teeth than in the Pittsburgh area exist within the U.S. For example he cited the case of Mandan, North Dakota, where tooth concentration are unusually high. Obviously many factors can affect the deposition, uptake into foliage, absorption by cows and excretion into milk of radionuclides, and differences in deposition alone may not be necessary to account for a 20% variation.

From the summary of human cancer production by radiation presented by the National Academy of Sciences in the report entitled "The Effects on Populations of Exposures to Low Levels of Ionizing Radiation" (the BEIR report) published in 1972, one can estimate the effect of a continuous whole body exposure of an excess of 200 mrem/year above background for 9 years, the time since Dr. Sternglass alleges excessive releases occurred. This assumption of dose, it should be emphasized, is a gross overestimate under the conditions stated by Dr. Sternglass, since he primarily was concerned about strontium isotopes unlikely to irradiate much beyond bony tissues. Nevertheless, on the basis of my own upper limit of all cancer cases (let alone deaths) which would be expected, 1.8 rem accumulated for this period should have increased all cancers in children and adults by about 18 per million population. Since it is unlikely that more than a few hundred or even thousand people could even conceivably have received this dose, the probability is well below unity that even one case could be observed. Note that this calculation neglects the latent period observed before cancer appears, which would require that radiogenic cancer cases could not yet be appearing for most cancers no matter what the dose. The risk of cancer in the developing fetus would be only 0.15 rem averaged over the time *in utero*, and although the estimates indicate about 8 cancer cases/million infants/year, the small number at risk would prevent any detection of this very small probability. These calculations illustrate why Dr. Sternglass should attempt to estimate doses if he sincerely believes that effects of radiation exposure from Shippingport have been observed in Beaver County, since he would be challenging in a major way the evidence on which the above risk estimates are based.

Validity of Dr. Sternglass' methods relating radiation exposure to health effects

Dr. Sternglass has generally relied on *changes in rates* of disease as the basis of his allegations of health effects. Thus when trends of cancer or infant mortality with time undergo changes in slope, this change is the datum, rather than the absolute rate itself. In effect, each population thus serves as its own control. Unfortunately for Dr. Sternglass, many of the disease categories he has studies are undergoing secular trends, which clearly indicate that prior to 1955 major environmental or other influences were affecting the rates, and the likelihood is that they still may account for some or all of the changes observed now. Also Dr. Sternglass has used crude rates for most of his figures not corrected for age, race, sex or other variables. The problem in this is that trends may be moving in opposite directions in different subgroups of the population exposed to the same radiation source. For example, Dr. Sternglass stated that total cancer death rates along the Ohio River have been going up since the early 1960's when radioactivity began to be released from Shippingport. A review of this question by Dr. Marvin Schneiderman of the National Cancer Institute shows that in representative counties, the rates for males, especially non-white, are going up, while in females, both white and non-white, the rates are going down over the time period in question (1950-1969). These trends are very comparable regardless of proximity to the Ohio River. They do not rule out Dr. Sternglass's conclusion, but they clearly indicate that cancer death rates are obviously highly influenced by many factors, both environmental and genetic, and to lump all groups together may lead to erroneous conclusions.

An important difficulty with the analysis of time trends in detecting radiation effects is the long latent period often observed between exposure and the development of disease. For prenatal irradiation this problem is less important, but most of Dr. Sternglass' presentation dealt with adults. I shall consider two examples to illustrate the problems associated with Dr. Sternglass' use of time trends in cancer rates, but I wish to emphasize that precisely the same arguments apply to all the other analyses of this type that he has presented where a latent period is expected.

The first is lung cancer, and the clearest illustrations are the graphs presented by Dr. Sternglass showing the respiratory cancer mortality rate for Midland, Beaver County and the state of Pennsylvania from 1957 to 1971, and the lung cancer mortality rate in Japanese males from 1947 to 1965. Copies of Dr. Sternglass' graphs are attached. In the latter case, data points are shown every two years, but it appears that a distinct rise from 1947-49 rates have already occurred by 1949-52, a conclusion evidently shared by Dr. Sternglass because he shows throughout this graph a five-year delay relating nuclear bomb events to the curve of mortality. (Why he did not include earlier data points is not clear.) In response to my questioning, Dr. Sternglass implied that the significant radiation source to account for this change was the plutonium resulting from bomb detonations. Plutonium particles inhaled at the time of the bomb would lodge in the bronchial epithelium and irradiate the sensitive cells over a long period of time with alpha radiation.

We have relatively good data relating alpha radiation exposures in the bronchi to lung cancer rates in underground mining populations, in terms of the time course of development of cases. To date the mean latent period is about 20 years from the beginning of exposure, with a significant rise in cases occurring initially at 9 to 10 years. This pattern is observed in all radiation dose ranges, including the highest doses, which are extremely high in comparison with doses one might expect from environmental sources after bomb tests or from reactors.

It is impossible to reconcile this time course of development of cases with the imputation of the rise of lung cancer in Japanese males to bomb detonations and release of plutonium. On the latter hypothesis the rise should have begun arount 1955 and slowly increased at an accelerating rate, in part because of the repeated tests, between

1955 and 1965. From a vast amount of data, we know that the really significant environmental change for these unfortunate cancer victims was the widespread introduction of cigarette smoking around 1920, with a latent period of about 25 years. Dr. Sternglass stated he had read the BEIR report from the National Academy of Sciences. In that report the evidence that lung cancer was occurring in the Japanese survivors of the bombing was reviewed. The excess cases have arisen only within the past decade, and only now 25-30 years after the bombing, become quantitatively important.

Turning to the graph of the respiratory cancer cases in Midland and Beaver County we find that Dr. Sternglass has related graphically the peak of cases in Midland in 1969 and 1970 to release of radioactive gases in 1963. In his testimony, moreover, he pointed out that the effect was subsiding, in that the rate in 1971 was back below Pennsylvania and Beaver County. Not only is this time course (rise and fall) totally inconsistent with the time course of any other radiogenic lung cancer studies, but the question of the radiation exposure is pertinent here. The implication of the graph is that the exposure is from inhaled radioactive gases from Shippingport. I questioned Dr. Sternglass closely on this issue, comparing radioactive gaseous releases from Shippingport with gaseous releases from the Dresden I reactor in Illinois, and he finally agreed that the latter consistently has released a thousand-fold greater amount than Shippingport. Thus if gaseous releases accounted for these cancer cases in Midland, the rise in lung cancer around the Dresden reactor should be the late 1960's have assumed catastrophic proportions, that is, nearly every adult over 40 should have developed lung cancer within a radius of five miles of the Dresden plant by now. No such increase has appeared, nor would we expect it to from the dose estimates I have made. It is evident from Dr. Sternglass' replies to my questions, however, that he does not really consider gaseous releases from reactors to be of much importance. Thus the Midland lung cancer "bump" would have to be ascribed to excessive releases and inhalation of particulates such as Sr-90, which Dr. Sternglass asserts took place around 1964. But of all the radiosensitive tissues irradiated by Sr-90 beta particles, the bronchial epithelium is one of the least affected by the relatively soluble strontium salts. There is, therefore, no biological basis for the allegation.

One final comment on the Beaver County respiratory cancer data on the same graph. It is evident from the argument presented above for the Japanese that no effect on lung cancer rates from any exposure to radioactivity from Shippingport, of whatever magnitude, would be expected until about 1970 or 1971, at the earliest, and in fact Dr. Sternglass' data do show merely random fluctuations around the Pennsylvania rate. If any significance were ascribed to the rise in 1968, expressed as a precentage of the 1959-61 rates as Dr. Sternglass usually plots such results, indicating radiation exposures 5 or 7 years earlier, we would expect from the miner model that the rate would have to increase progressively in 1969, 1970, and 1971. The failure for this to occur is strong evidence that the 1968 "peak" could not be radiogenic in origin.

The second type of cancer I wish to consider is relation to these time trends is leukemia. Dr. Sternglass has plotted the data for Beaver County and Pennsylvania in a graph entitled "Percent changes in mortality rates: Leukemia and other cancers of the lymphatic and hemapoietic system relative to 1959-61." This graph is also attached. Here the data are expressed as a percentage of the baseline period 1959-61. Two early "peaks" in 1962 and 1965 are ascribed, by implication anyway, to Nevada tests in 1958 and a gaseous release from Shippingport in 1961. As far as the nevada tests in 1958 and 1962 are concerned, we should, on Dr. Sternglass' assumptions, expect Pennsylvania to be affected generally, and indeed, slight "peaks" are discernible in 1962 and 1966 for the Pennsylvania data. From the large number of studies in human populations done with regard to leukemia in relation to radiation exposures, we know that the incidence begins to increase about 2 years after exposure, rises to a peak around 5 to 10 years after exposure and then subsides somewhat. The "peaks" for either Beaver County or Pennsylvania prior to 1967 are thus not consistent with this time course and can be given no weight whatever, expecially the Beaver County data which show merely magnified random fluctuations up to 1966.

The higher percent increases in Beaver County from 1967 on, however, would be consistent with bone marrow exposure to radiation around 1964 or 1965. It would not be consistent with the timing of the gaseous release shown on the graph by Dr. Sternglass, expecially because Dr. Sternglass himself does not really think radioactive gases from Shippingport are very important in terms of radiation exposures to citizens of Beaver County. The release of Sr-90 or Sr-89 postulated by

Dr. Sternglass around 1964 could be related, in terms of the timing at least, to this apparent rise in leukemia death rates. To settle the question requires answers to the following questions: Are the types of leukemia or other cancers those known to be induced by radiation? And, is there any evidence that _significant_ amounts of Sr-90 are present in bones of people living near the reactor? In view of the furor that Dr. Sternglass' assertions have made, a few analyses of bones from accident victims of different ages would seem to be in order to settle this question. There is however a major discrepancy between Dr. Sternglass' data and results shown by Dr. Tokuhata. For 1969-71 Dr. Tokuhata found only a slight difference in leukemia rates for Beaver County compared with Pennsylvania, the difference being due solely to slightly higher rates of lymphatic leukemia and Hodgkin's disease. This discrepancy suggests that Dr. Sternglass has used percent changes in this graph with a base in 1959-61 when leukemia rates were if anything unusually low in Beaver County.

Adequacy of health data on which alleged radiation effects are based

I have already indicated that if health data are to be used in the way Dr. Sternglass had employed them, then age-adjusted rates by sex and race for specific radiogenic types of cancers for for specific types of heart disease should be used where at all possible. If such adjusting data are not available then it is likely that the group should not be used for such comparisons. In general, populations of a few thousands can yield meaningful adjusted data for at least the commoner types of disease.

Demographic data of the kind cited above are usually more readily available than are the specific population figures to which the disease rates must apply. An example of the difficulty in determining rates arose in calculating infant mortality rates in Aliquippa. Careful evaluation on each individual case in 1971 by Dr. Tokuhata and his associates has shown that when the proper population base is used for comparison, or cases properly assigned to location, the difference in rate compared with Pennsylvania as a whole larely disappears. In other words the data regularly reported by the Health Department may contain major defects, a fact that both Dr. Speller and Dr. Bachman recognize. Errors of this type, relating to the place of residence of individuals dying in a nearby city or town are significant especially when one compares rates in small communities with relatively few cases, as Dr. Sternglass has done extensively. It is not Dr. Sternglass' fault that the data are unreliable, but it is incumbent on anyone who uses this information to recognize some of its limitations.

Not only are the appropriate populations to which cases must be applied to calculate rates often in error, but the cases themselves are misassigned into disease categories, expecially with death certificate data are used. This source of error is well-recognized in work of this type, and for large populations one can usually correct for it. But for small communities the errors of diagnosis and reporting may differ significantly from one location to another. Although we hope health data can be improved to minimize these errors, a major effort and expense would be required. At the very least the public should be made aware that the published numbers are not necessarily holy writ from on high. Certainly any groups using health data to determine risks of environmental hazards are duty bound to take steps to recognize any errors of this type, and qualify their conclusions accordingly.

Summary and Conclusions

1. Dr. Sternglass' contention that unrecognized releases of airborne radioactive particulates occurred from Shippingport in 1964 or 1970 is not generally supported, but the monitoring data are not adequate to rule out some distribution of Sr-90. Steps should be taken by the state to resolve this issue by checks of the Sr-90 content of milk in the Aliquippa area, and of bones of accident victims in Beaver County.

2. Weaknesses in the environmental monitoring program around reactors should be strengthened, preferably by levying a millage charge on electric power generation in Pennsylvania, thus providing funds for an expanded state monitoring program independent of the utilities.

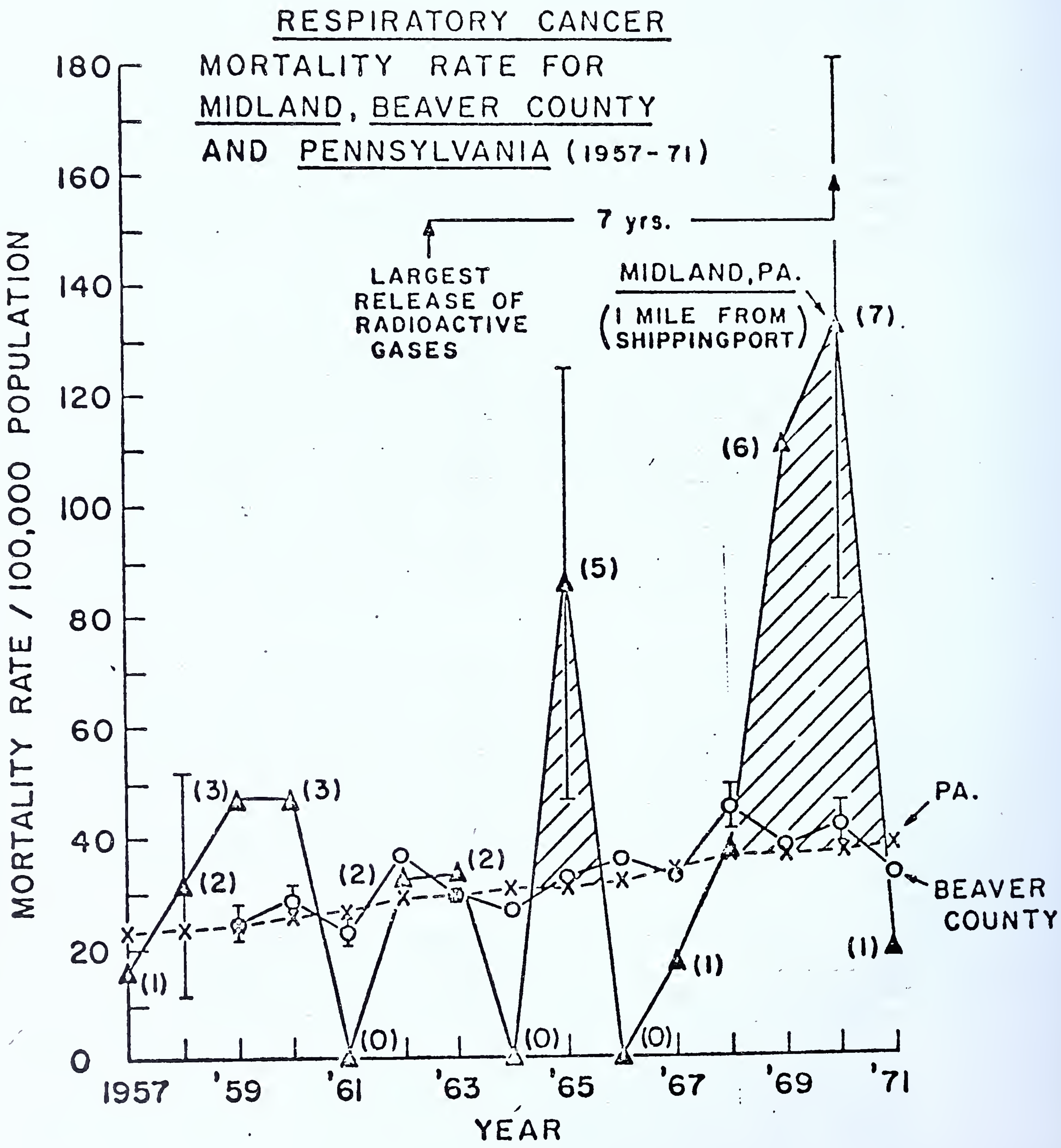
3. No significant health effects, including infant mortality, have been found in Aliquippa or Beaver County that cannot be explained by reporting errors, or other well-known sociological or other characteristics of the population. Dr. Sternglass' method of studying time trends of health indicator rates is particularly weak in evaluating health effects of environmental agents in small communities.

4. Dr. Sternglass' failure even to estimate radiation doses to the tissues in some of the populations for which he is alleging health effects is a major abrogation of his scientific responsibility. He is unusually qualified to make such calculations, which should be central to his whole thesis. Moreover, his evaluation of time trends of cancer or heart disease rates in relation to possible radiation exposures is inconsistent with the time course of radiation effects derived from studies of a great many other investigators. For these reasons the basis of his evidence of effects on cancer and heart disease rates from radiation exposure must be considered to be spurious.

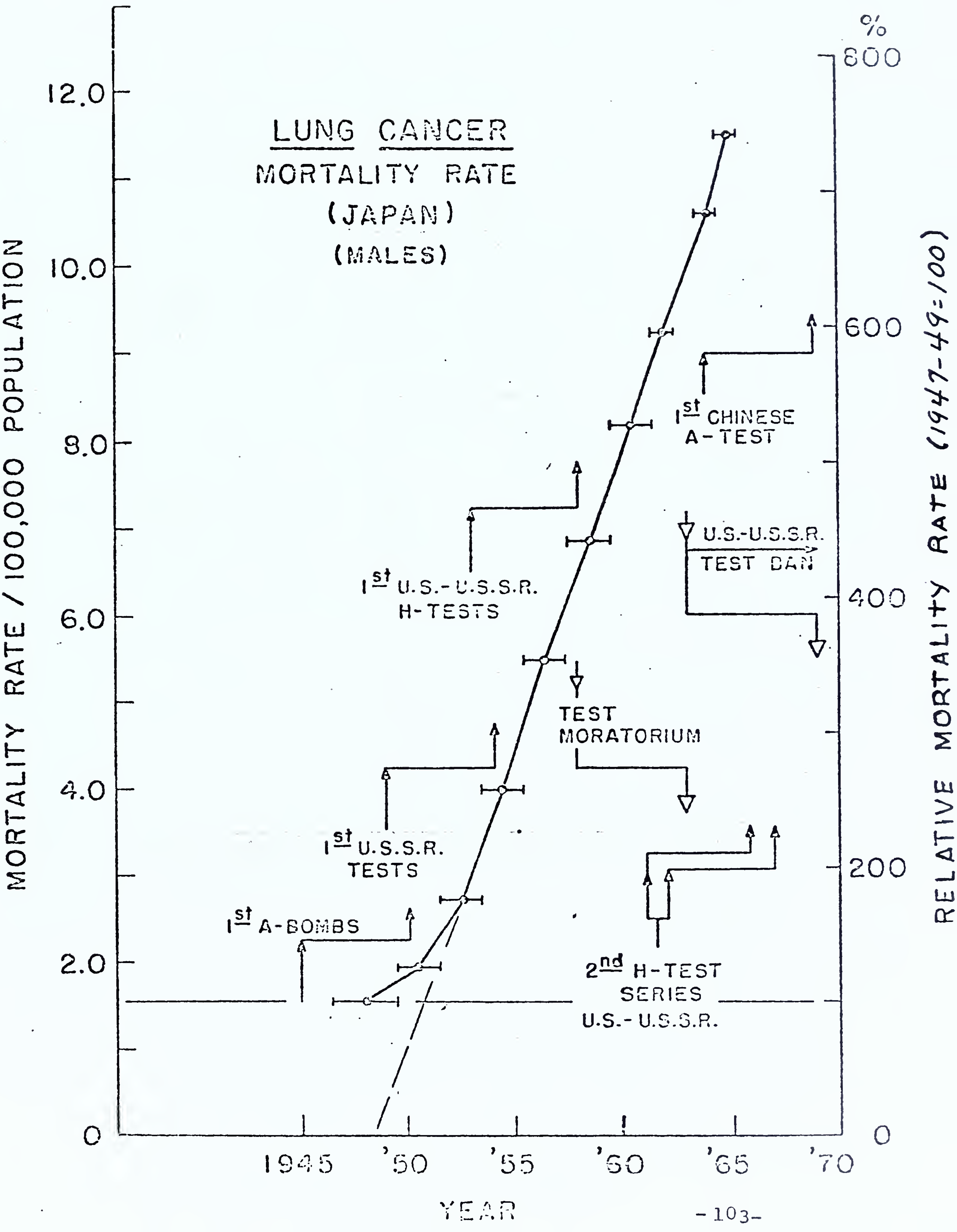
5. Although many of the fears of nuclear power development among the general public may have derived from an uncritical acceptance of unsubstantiated claims by Dr. Sternglass or others, these fears are genuine and must be kept clearly in mind in future governmental policies by the Governor and state officials. Some concerns about nuclear power development are valid, in my opinion, most notably the reliability of breeder reactors, on which the long-term development of fission reactors depends critically at this time, and long-term waste disposal. It would be a serious mistake to dismiss the protests of citizens about nuclear power plants as representing statements of a lunatic fringe with no substance.

6. Because of these concerns, it is especially important that there be an opportunity for a full public discussion of the power generation alternatives long before a plant is proposed, designes settled, and a site selected. This is particularly important for Pennsylvania with its extensive coal reserves, the mining of which carries its own very significant health and environmental costs. The current energy crisis should not be a signal to stampede into just any solutions of our power needs.

7. The format of the Aliquippa hearings proved to be satisfactory to both sides in this issue, in contrast to the legalistic type of public hearing that is usual in matters of government policy these days. Especially important was the opportunity for those testifying to be questioned by people with expert knowledge in the field under discussion. The success of the hearings rests on whether the Committee members were expert enough to bring out all the details necessary.



RESPIRATORY CANCER MORTALITY RATE FOR MIDLAND, BEAVER COUNTY AND PENNSYLVANIA (1957-71)


LUNG CANCER
MORTALITY RATE
(JAPAN)
(MALES)
MORTALITY RATE / 100,000 POPULATION
RELATIVE MORTALITY RATE (1947-49=100)
%
12.0
10.0
8.0
6.0
4.0
2.0
0
800
600
400
200
0
1945
'50
'55
'60
'65
'70
YEAR
1st A-BOMBS
1st U.S.S.R. TESTS
1st U.S.-U.S.S.R. H-TESTS
TEST MORATORIUM
1st CHINESE A-TEST
U.S.-U.S.S.R. TEST BAN
2nd H-TEST SERIES U.S.-U.S.S.R.

PERCENT CHANGES IN MORTALITY RATES LEUKEMIA AND OTHER CANCERS OF LYMPHATIC AND HEMAPOIETIC SYSTEM RELATIVE TO 1959-61, BEAVER COUNTY

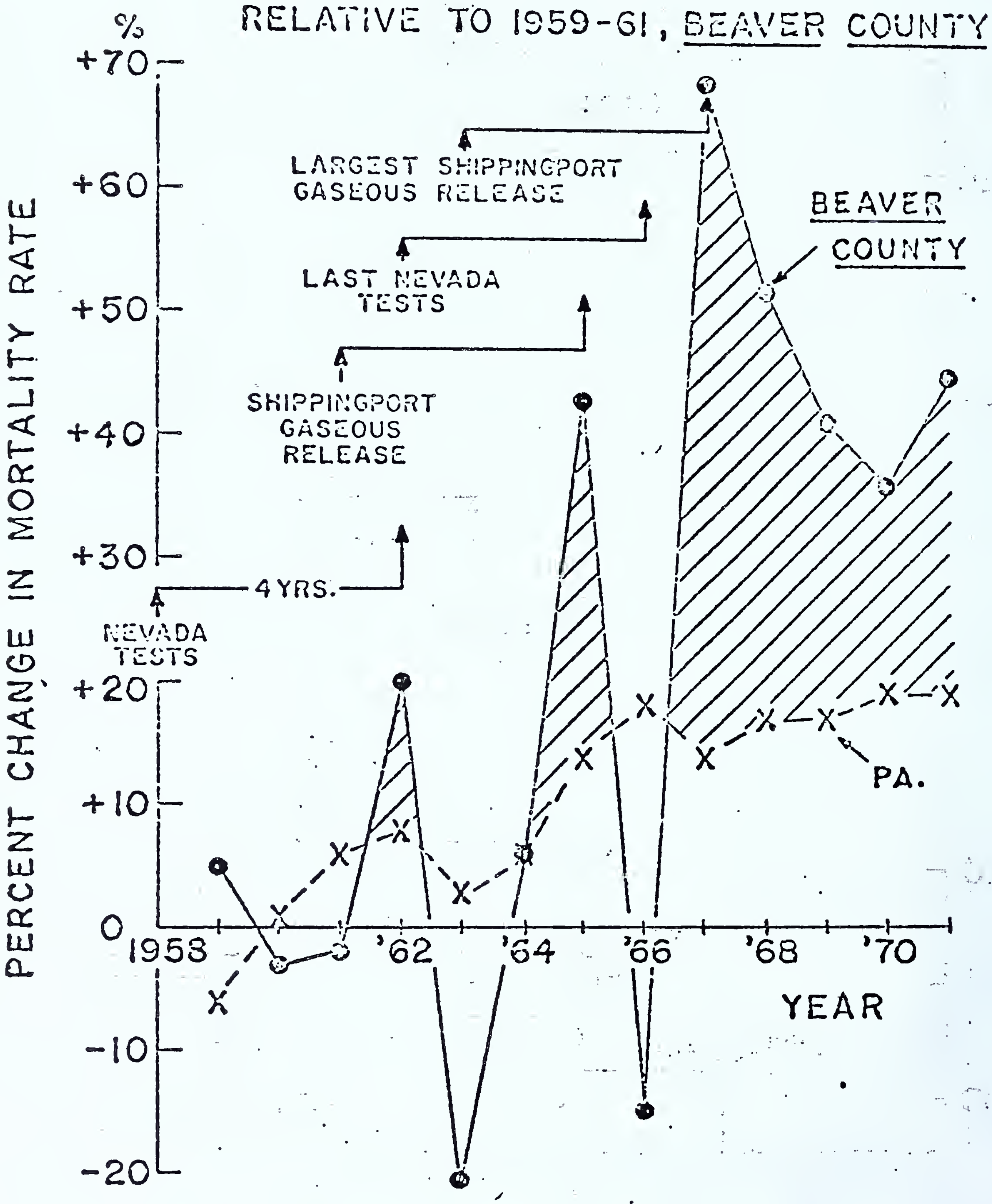


FIG.3

COMMENTS OF MORRIS H. DeGROOT

In my view there were two important and distressing facts which emerged from the Committee's investigation. First, we learned that the area near the Shippingport reactor, there has been no regular reliable monitoring of radiation in the environment. Therefore, it is not now possible to determine whether or not there were unreported large releases of radioactivity from the reactor in 1972 or earlier, nor is it possible to determine the amounts of radioactivity from the reactor and other sources to which the populations of nearby communities have been exposed.

Second, the anomalous levels of radioactivity found by the NUS Corporation in their pre-operational monitoring program for the Beaver Valley Power Station seem to have been accepted without further investigation by the Duquesne Light Company and the Atomic Energy Commission until Professor Sternglass publicized these findings. A reanalysis was then carried out in an attempt to discredit the findings. However, because of the tendentious nature of this reanalysis, it must also be regarded as unreliable.

Thus, in the matter of low-level radiation, the people living in the Shippingport area have been forced to rely on, and to trust their health to, agencies which have been distressingly derelict in their duties. These agencies have not provided the people with the protection and safety that they assumed they were getting. Professor Sternglass is to be commended for bringing to the attention of the general public this significant shortcoming of the nuclear energy program.

It does not seem possible to ascertain on the basis of published data whether or not the operation of the Shippingport reactor, or of other nuclear reactors, has had an adverse effect on our health. Professor Sternglass has been critized for basing his allegations only on crude published mortality data, but those are the only data available. The criticism here should more properly fall on the public agencies that have neither collected nor published the detailed health and radiation data that are necessary for a careful statistical analysis of this problem. It would be a mistake for us to reject Professor Sternglass' allegations simply because we find his statistical methods inadequate.

There are two types of errors that we could make in our public policy. On the one hand, we could assume that the routine low-level releases from nuclear reactors are relatively harmless when, in fact, they pose a health hazard to infants and other susceptible groups. On the other hand we could assume that the routine low-level releases are harmful when in fact they are relatively harmless. The consequences of this type of error would be for our society to forego unnecessarily the great benefits of nuclear energy.

We face here a problem of public decision making under uncertainty in which both types of errors have serious consequences. I propose a full scale interdisciplinary study of low-level radiation and health, to be carried out by an independent commission appointed at the federal level. A study of this kind could provide information that would significantly reduce the probability of our making either type of error. It could go far toward bringing the scientific community and the general public into agreement about the risks and the benefits of nuclear reactors.

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